1996 HSC CHEMISTRY

DETAILED SUGGESTED SOLUTIONS

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SECTION I: CORE

PART A

l. ANS A

A substance will conduct electricity if there are either electrons or ions free to move. Neither sulfur (S) nor silicon dioxide (SiO_2) has free electrons or ions in either the solid or liquid states. Lithium fluoride has free ions in the liquid state but has neither free electrons nor free ions in the solid state. Only sodium metal has free electrons in both the solid and liquid states.

2. ANS B

K_a is an equilibrium constant. As the temperature changes so too does the value of the equilibrium constant.

3. ANS D

Solid iodine contains diatomic molecules with strong covalent bonding within the molecules and weak dispersion forces between the molecules. These attractive forces between the iodine molecules are overcome when solid iodine is heated.

4. ANS C

X is element 14 (silicon) and Y is element 17 (chlorine). These elements will form the covalent compound $SiCl_4$.

5. ANS C

Choose the longest possible carbon chain containing the double bond. This is 6 carbons in length. Hence, the compound is hexene. There are two methyl groups on the 4th carbon atom. Hence, the IUPAC systematic name of this compound is 3-iodo-4,4-dimethyl-1-hexene.

6. ANS D

From the graph, it can be seen that the concentrations of both reactants and products become constant after about **four** hours. Equilibrium has been reached. The reaction did not go to completion because there are some reactants remaining. The equilibrium concentrations are **not** 0.2 mol L^{-1} . The forward reaction has **not** stopped. This is dynamic equilibrium. The rate of the forward reaction is equal to the rate of the reverse reaction.

7. ANS A

The strong oxidising agent, hot, acidified potassium permanganate will oxidise 1-butene to propanoic acid and carbon dioxide according to the partial ionic equation:

$$C_4H_8(g) + 4H_2O(l) = CH_3CH_2COOH(aq) + CO_2(g) + 10H^+(aq) + 10e^-$$

8. ANS A

From the graph, it can be seen that the original pH of the acid is approximately 3. This is the pH of a relatively weak acid. Therefore, the acid cannot be hydrochloric acid, nitric acid or sulfuric acid since these are strong acids. Of the choices given, it must be ethanoic acid.

SECTION I: CORE

PART A

9. ANS C

The greater the equilibrium constant, the greater the tendency to reach completion. Hence, the order of increasing tendency to reach completion is IV , II , III , I.

(**IMPORTANT NOTE**: This procedure is only valid for reactions at the same temperature which have the same stoichiometry - that is, the same units for K in the equations used. In this question, it is only possible to compare K values for I with III (Units M) and II with IV (No units), assuming the same temperature applies throughout.)

10. ANS A

The strongest acid is the acid with the lowest pH since all solutions contain equal concentrations of monoprotic acids at the same temperature. Acid A.

1 l. ANS D

Isomers are the same molecular formula but different structural formulae. Methylcyclopentane has the molecular formula C_6H_{12}. Hexane has the molecular formula C_6H_{14}. They are not isomers.

12. ANS B

For the weak acid HCN, assume that at equilibrium [CN-] = [H+] and [HCN] = 0.1 M.

Hence, $K_a = \frac{[CN^-][H^+]}{[HCN]} = \frac{[H^+]^2}{0.1} = 6.17x10^{-10}$

$[H^+]^2 = 6.17 \text{ x } 10^{-11}$

$[H^+] = 7.85 \text{ x } 10^{-6}$

pH = 5.10

13. ANS C

The yield of NH_3 will be increased by **decreasing** the temperature, **increasing** the pressure and **increasing** the amount of H_2 gas.

Increasing the amount of N_2 gas will also increase the yield of NH_3.

IMPORTANT NOTE: This information does not correspond with actual industrial practice. The industrial process is not done under equilibrium conditions. Instead, high temperatures are used in conjunction with high pressures of reactants and the ammonia is drawn off constantly. The high temperature is used because all reactions (including those that are exothermic) proceed more rapidly when the molecules have more energy. For the equilibrium system, high temperature would reduce the concentration of ammonia.

14. ANS D

To reduce acidosis, the $[H^+]$ must be reduced. According to the equilibrium equation, this could be done by removing CO_2 from the equilibrium, thereby forcing the equilibrium to the left.

15. ANS B

The separation of the product from the reaction mixture is done by distillation. The product is drawn off at its boiling temperature. as indicated by the thermometer.

PART B

16. The table can be completed in the following way.

	Oxide of sodium	Oxide of sulfur
Formula	Na_2O	SO_2 or SO3
Type of bonding	ionic	covalent
Litmus colour in aqueous solution	blue	pink

PART B

17. From the equilibrium equation: $K = \frac{[C]^3}{[A][B]}$

The number of moles of A , B and C at equilibrium can be obtained from the graph.

Equilibrium is reached when the number of mole of each becomes constant over time.

At equilibrium, [A] = 4/2 = 2.0 M

[B] = 1/2 = 0.5 M

[C] = 3/2 = 1.5 M

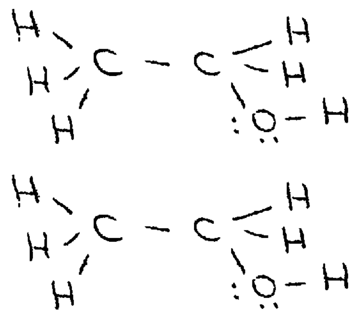
$$K = \frac{(1.5)^3}{(2.0)(0.5)}$$

$= 3.4$ M **ANS**

PART B

18.

(a) Both ammonia and ethanol exhibit hydrogen bonding in the liquid state. In ethanol , electrostatic attraction between the lone pair of electrons on the O atom of one CH_3CH_2OH molecule and an H atom of another CH_3CH_2OH molecule is the cause of the hydrogen bonding. This is shown below.



(b)

(i) Dispersion forces are the major intermolecular forces present in methane.
Also dispersion forces are the major intermolecular forces present in non-hydrogen bonded polar molecules such as propanone and chloromethane.

(ii) Dipole - dipole forces will be present (but will not be as significant as dispersion forces) in the polar molecules propanone and chloromethane.

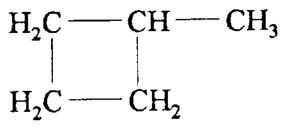
PART B

19.

(a) The formula C_5H_{10} indicates either an alkene or a cycloalkane. The hydrocarbon which decolourisers bromine could be an alkene, while the other hydrocarbon could be a cylcoalkane. Possible structures for each include the following.

Alkene : $H_2C = CH - CH_2 - CH_2 - CH_3$

Cycloalkane:



(b) The balanced equation for the addition reaction of the alkene with bromine is

$H_2C = CH - CH_2 - CH_2 - CH_3 + Br_2 = CH_2Br- CHBr- CH_2 - CH_2- CH_3$

PART B

20.

(a) The expression for the equilibrium constant for this equation is:

$$K_c = \frac{[CH_4(g)][H_2S(g)]^2}{[CS_2(g)][H_2(g)]^4}$$

(b) The value of the equilibrium constant at this temperature is given by:

(Notice that each of the number of mole must be divided by 5.0 L to give the equilibrium concentrations.)

$$K_c = \frac{(0.55/5)(0.125/5)^2}{(0.15/5)(0.15/5)^4} = 2.83 \times 10^3 \ M^{-2}$$ **ANS**

PART B

21.

(a) Ethene contains only carbon and hydrogen atoms covalently bonded and is non-polar. Thus ethene cannot interact with water molecules by ionic dissociation, hydrogen bonding or through other intermolecular forces involving dipole moments, all of which would aid dissolution.

(b)

(i) Ethene molecules contain a region of high electron density where the double bond joins the two carbon atoms. This electron-rich region allows a halogen molecule to add to ethene, breaking the second carbon-carbon bond in the process.

Ethane has no such region of high electron density and the mechanism by which halogens react with ethane is from UV light or heat generating halogen atoms which substitute for H atoms in ethane - a much slower process.

(ii) The balanced equation is $CH_3 - CH_3(g) + Cl_2(g) \overset{\text{U.V light}}{=} CH_3CH_2Cl(g) + HCI$

PART B

22.

(a) The equilibrium constant is given by the expression

$$K_c = \frac{[CS_2(g)]}{[S_2(g)]}$$

Note that carbon is not included because it is a solid

The initial value of $K_c = \frac{[CS_2(g)]}{[S_2(g)]}$ = 1, as equal moles are used.

However, the equilibrium value of the expression is K_c= 5.60. Therefore it is necessary for the [CS_2(g)] to increase and the [S_2(g)] to decrease until this equilibrium value is reached. Thus the **forward reaction** will predominate until equilibrium is reached.

(b) If the pressure in the container is increased by decreasing the volume, there will be no change as the equation has the same number of moles of gaseous species on both sides.

PART B

23.

(a) The relative formula mass of $Ba(OH)_2$ = 137.30 + 32.00 + 2.02 = 171.32

(b)

(i) $[Ba(OH)_2]$ = 0.857/171.32 mol in 0.250 L

i.e. (0.857/171.32) x 4 mol in 1 L = $2.00 \times l0^{-2}$ M

There are 2 OH^- ions in the formula.

Hence, [OH-] = 2 x 2.00×10^{-2} M = 4.00×10^{-2} M

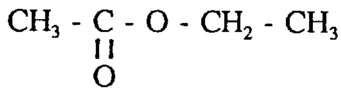
(ii) pOH = $-\log_{10} (4.00 \times 10^{-2})$ = 1.40

pH = 14 - pOH = 12.60 **ANS**

PART B

24.

(a) The structural formula of ethyl ethanoate is



(b) The preparation of ethyl ethanoate from ethanol as the only organic starting material is shown in the equations below.

$$CH_3CH_2OH \xrightarrow{KMnO_4/H^+} CH_3COOH$$

$$CH_3COOH + CH_3CH_2OH \xrightarrow[\text{conc. } H^+]{\text{reflux}} CH_3COOCH_2CH_3$$

PART B

25.

(a) Sodium sulfate can be formed in an acid-base reaction from sodium hydroxide and sulfuric acid as shown by the equation:

$$2NaOH(aq) + H_2SO_4(aq) = Na_2SO_4(aq) + 2H_2O(l)$$

(b) The ethanoate ion, CH_3COO^-, is a weak base which means that a small proportion of it reacts slightly with water to form its conjugate (ethanoic acid) and hydroxide ions in the equilibrium

$$CH_3COO^-(aq) + H_2O(l) = CH_3COOH(aq) + OH^-(aq)$$

The OH^- ions produced cause the pH to be greater than 7.

On the other hand, the sulfate ions present in a solution of sodium sulfate react with water to such a small extent that the pH remains almost unchanged from 7.

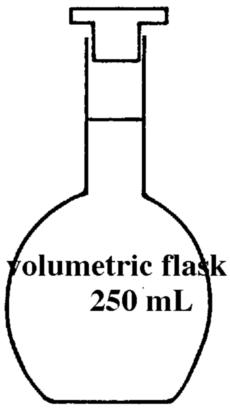
PART C

26.

(a) Hydrated solid sodium carbonate can be converted to the anhydrous form by heating in an oven at 100°C. The water is removed in the reaction:

$$Na_2CO_3.10H_2O(s) = Na_2CO_3(s) + 10H_2O(g)$$

(b) The glassware in which the sodium carbonate was prepared is a volumetric flask. This flask is shown below.



(c) The balanced equation for the reaction is:

$$Na_2CO_3(aq) + 2HNO_3(aq) = 2NaNO_3(aq) + CO_2(g) + H_2O(l)$$

(d) Average volume of HNO_3 (titrations 2, 3, 4) = 24.77 mL

$n(Na_2CO_3)$ in 25.00 mL = 0.0250 x 0.100 = 2.50 x 10^{-3} mol

1 mole Na_2CO_3 reacts with 2 moles HNO_3

$n(HNO_3)$ in 24.77 mL = 2 x 2.50 x 10^{-3} = 5.00 x 10^{-3} mol

$n(HNO_3)$ in 1000 mL = 5.00 x 10^{-3} x 1000/24.77 mol

$[HNO_3]$ = 0.202 M **ANS**

PART C

27.

(a) Since the solution colour was blue, the pH is greater than 7 and therefore, the solution contains an excess of hydroxide ions. The balanced equation for the reaction is:

$KNO_2(s) = K^+(aq) + NO_2^-(aq)$

and then

$NO_2^-(aq) + H_2O(l) = HNO_2(aq) + OH^-(aq)$

(b)

(i) From bromothymol blue, pH ≥ 7.6

From thymol blue, pH ≤ 8.0

pH lies between 7.6 and 8.0 **ANS**

(ii) $[H^+]$ lies between $10^{-7.6}$ M and $10^{-8.0}$ M

As $[H^+][OH^-] = 10^{-14}$ at 25°C,

then $[OH^-]$ lies between $(10^{-14} / 10^{-7.6})$ and $(10^{-14} / 10^{-8.0})$

4×10^{-7} M ≤ $[OH^-]$ ≤ 1×10^{-6} M **ANS**

(c) The equivalence point is at the pH corresponding to the midpoint of the steep fall in the graph. This occurs at pH ≈ 5.5. An indicator is required that changes colour during the addition of the smallest possible amount of acid. Therefore methyl red would be a suitable indicator.

(d) Acid-base indicators are themselves weak acids or bases and therefore also react with the solutions used in the titration. To avoid error from this source, the minimum amount of indicator should be used. Also, it is difficult to visually detect colour change when the colour is too intense which would be the case if too much indicator were used.

PART C

28.

(a)

(i) The small value of K shows that the equilibrium lies to the left hand side and the concentrations of $Fe(SCN)^{2+}$ and OH^- will be much less than the concentrations of the reactants.

(ii) Depending on the concentrations used, the colour will be yellow-orange.

(b) Dry ice is solid CO_2 which reacts with OH^- according to the equation:

$$CO_2(g) + 2OH^-(aq) = CO_3^{2-}(aq) + H_2O(l)$$

When all the OH^- is removed, further reaction of CO_2 with water causes the solution to become acidic according to the equation:

$$CO_2(g) + H_2O(l) = H_2CO_3(aq) = H^+(aq) + HCO_3^-(aq)$$

(c) The CO_2 reacting with OH^- causes the equilibrium to shift to the right, according to Le Chatelier's Principle, which leads to a greater concentration of the bright red $Fe(SCN)^{2+}$ ion.

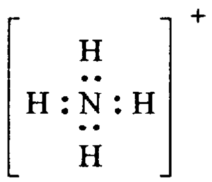
PART C

29.

(a) The balanced equation for the reaction is:

$NH_3(g) + HCl(g) = NH_4Cl(s)$

(b) An ‘electron-dot’ formula for the ammonium ion is shown below.



(c) The electron configuration for the chloride ion is l s^2 2 s^2 2 p^6 3 s^2 3 p^6

(d) When the ammonium ion is formed from the ammonia molecule, a coordinate covalent bond is formed.

(e) Ammonium chloride is an ionic compound. Ionic compounds are solids at room temperature because they consist of large numbers of oppositely charged ions held together by electrostatic attractive forces in a crystal lattice. Hence, ammonium chloride is a solid at room temperature and pressure.

PART C

30.

(a) Copper is a good conductor of heat and electricity because copper has metallic bonding in which atoms are held together by mobile outer electrons which readily move between atoms. These mobile electrons can be induced to flow through metal by an applied voltage. The close packed copper ions in this sea of electrons can vibrate easily and pass this energy (heat) through the copper metal.

(b) Diamond is one of the hardest known substances because diamond consists of an infinite array of covalently bonded carbon atoms arranged so that each is bonded to four other tetrahedrally disposed carbon atoms. This very stable structure requires considerable energy to break the bonds.

(c) Water has a higher boiling point than hydrogen sulfide because the molecules of water are extensively hydrogen bonded to each other. To boil water, individual molecules must be given sufficient energy to escape from the liquid to the gas phase. Breaking hydrogen bonding in the liquid requires additional energy, leading to a higher boiling point than expected on the basis of relative molecular mass.

(d) Ethanol readily dissolves in water because ethanol hydrogen bonds to water molecules because it has an -OH group in its molecule like water which, of course, forms hydrogen bonds with itself. This hydrogen bonding leads to a lower energy system when ethanol dissolves in water, thereby enhancing its solubility.

(e) Helium has an extremely low boiling point because being a small, monatomic element, helium has only very weak dispersion forces operating in the liquid phase. Consequently only a small amount of energy is needed to allow helium atoms to escape to the vapour phase.

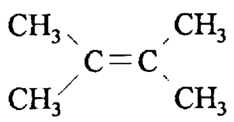
PART C

31.

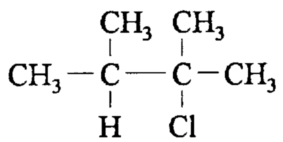
(a) Since the empirical formula is CH_2 and molar mass is 84 g mol^{-1}, the molecular formula of A must be $(CH_2)_6 = C_6H_{12}$.

(b)

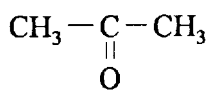
(i) The structural formula of A is shown below.



(ii) The structural formula of C is shown below.



(iii) The structural formula of D is shown below.



(c) Compound E has the IUPAC systematic name 2,3-dimethyl-2,3-butanediol.

SECTION II: THE ELECTIVES

CHEMICAL ENERGY

32.

(a)

(i) The volume of the gas increases as the pressure decreases.

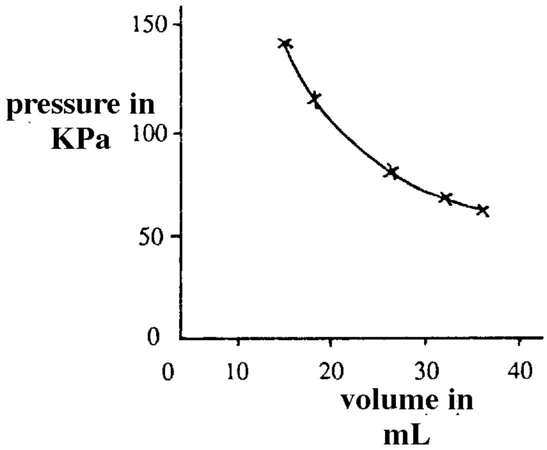
(ii) From these results, it can be seen that

Pressure x volume = constant

or

$P_1 \times V_1 = P_2 \times V_2$

(iii) The graph of this relationship is shown below.



(iv) $P_1 \times V_1 = P_2 \times V_2$

$148 \times 15 = 160 \times V_2$

$V_2 = 14$ mL **ANS**

(v) At very high pressures the actual volume of the gas molecules themselves becomes significant instead of being negligible as it is at lower pressures. Consequently the gas behaves as if it were in a smaller container and the actual pressure would be higher than predicted by equation. The ideal gas equation no longer applies.

(vi) $PV = nRT$.

$n = PV/RT = (148 \times 0.015)/ (8.314 \times 298)$ mol $= 9.0 \times 10^{-4}$ mol **ANS**

(vii) As the pressures used are not high, the same result should be observed because the relation is independent of the gas used.

SECTION II: THE ELECTIVES

CHEMICAL ENERGY

(b)

(i) Ethyne (also called acetylene) is mostly used in oxy-acetylene blowtorches for cutting and welding metals.

(ii) The balanced equation for the reaction is:

$2C_2H_2(g) + 5O_2(g) = 4CO_2(g) + 2H_2O(g)$

[N.B. The definition of Heat of Combustion usually specifies $H_2O(l)$ as the product, but required data has not been supplied.]

Bonds broken:	Bonds formed:
2 mole C - C = 2 x 839 kJ = 1678 kJ	8 mole C - O = 8 x 804 =6432 kJ
4 mole C- H = 4 x 414 = 1656 kJ	4 mole H - O = 4 x 463 = 1852 kJ
5 mole O - O = 5 x 498 = 2490 kJ	
Total = 5824 kJ	Total = 8284 kJ

ΔH^0 = Σ(bond enthalpies for bonds broken) - Σ (bond enthalpies for bonds formed)

= 5824 - 8284

= -2460 for 2 mole of ethyne.

Heat of combustion is defined as being - ΔH for the reaction.

Therefore the heat of combustion of ethyne = 1230 kJ mol-1 **ANS**

SECTION II: THE ELECTIVES

CHEMICAL ENERGY

(c)

(i) ΔH = mass of solution x specific heat x ΔT

As density = 1.0 g mL-1 and volume = 100 mL, mass = 100 g

ΔT = 33.4 - 20.5 = 12.9°C

ΔH = 100 x 4.18 x 12.9 = 5392 J from 4.0 g NaOH

1 mole NaOH = 40.0 g

moles of NaOH used = 0.10 mol

For 1 mole NaOH, ΔH = 10 x 5392 J mol^{-1} = 54 kJ mol^{-1}

Because this was heat released (T increased), the sign of ΔH is negative.

ΔH = -54 kJ mol^{-1} **ANS**

(ii) For 1 mole of solid NaOH reacting with sulfuric acid, 54 kJ of heat was released. However, 43 kJ of this heat was due to the solid sodium hydroxide dissolving in the water. Therefore, for the reaction

$H^+(aq) + OH^-(aq) = H_2O(l)$

ΔH = -54 - (-43) = - 11 kJ mol^{-1} **ANS**

(iii) 1. Three pieces of equipment that are necessary for the experiment are:

*volume measuring apparatus such as a measuring cylinder;
*calorimeter equipped with a stirrer;
*thermometer.

2. If 0.10 mole of NaOH is required, then volume of 2.0 M NaOH

= (0.1 x 1000)/2.0 = 50 mL **ANS**

The minimum volume of 1.0 M H_2SO_4 required for complete reaction would contain 0.050 mole H_2SO_4.

minimum volume H_2SO_4 = (0.050 x 1000)/1.0 = 50 mL **ANS**

Together, these would give a final volume of solution = 100 mL

SECTION II: THE ELECTIVES

CHEMICAL ENERGY

3. The main sources of error are heat loss from the calorimeter and errors in reading the thermometer. Heat loss can be reduced by using a well insulated calorimeter while errors in temperature readings can be minimised by using a narrow range thermometer where the scale is large.

(d) If the physical states of reactants and products are taken as in the following equation,

$C_2H_5OH(l) + 3O_2(g) = 2CO_2(g) + 3H_2O(l)$

then $\Delta H°$ $= \Sigma[\Delta H°_f \text{ (Products)}] - [\Delta H°_f\{\text{Reactants})]$

$= [2 \times (-394) + 3 \times (-286)] - [(-235) + 0]$

$= -1411$ kJ for the combustion of 1 mole ethanol.

Moles of ethanol in 100 g = 100/46.1 = 2.169 mol.

Heat evolved from 100 g ethanol = -1411 x 2.169 kJ = -3060 kJ **ANS**

(e)

(i) One advantage of hydrogen as a fuel is that for a given mass of hydrogen, the amount of heat released is relatively large.

(ii) One disadvantage of hydrogen as a fuel is that for a given volume, it is necessary to use hydrogen in the liquid form (as in the space shuttle) to obtain significant energy. This is not convenient due to the high pressure and low temperature required. Another disadvantage is that hydrogen gas forms an explosive mixture with oxygen gas

(iii) The balanced equation for the reaction is:

$2C_8H_{18}(l) + 25O_2(g) = 16CO_2(g) + 18H_2O(l)$ $\Delta H = -10940 \text{ kJ mol}^{-1}$.

It is important to note that the mol^{-1} means per mole of equation **as written**.

That is, -10940 kJ for the combustion of 2 mole of octane.

SECTION II: THE ELECTIVES

OXIDATION AND REDUCTION

33.
(a)

(i) The balanced half-equation is:

$C_2H_5OH(l) + H_2O(l) = CH_3COOH(aq) + 4H^+(aq) + 4e^-$

This is an oxidation reaction since electrons are given up.

(ii) The balanced half-equation is:

$Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^- = 2Cr^{3+}(aq) + 7H_2O(l)$

(iii) The simplest whole-number redox reaction is:

$3C_2H_5OH(l) + 2Cr_2O_7^{2-}(aq) + 16H^+(aq) = 3CH_3COOH(aq) + 4Cr^{3+}(aq) + 11H_2O(l)$

(iv) From (iii), 1 mole $Cr_2O_7^{2-}$ reacts with 1.5 mole C_2H_5OH

$n(Cr_2O_7^{2-})$ used = 0.0425 x 0.0100 = 4.25 x 10^{-4} mol

$nC_2H_5OH)$ in 50 g plasma = 1.5 x 4.25 x 10^{-4} mol

In 100 g plasma, $nC_2H_5OH)$ = 2 x 1.5 x 4.25 x 10^{-4}

= 12.8 x 10^{-4} mol

1 mole C_2H_5OH = 46.1 g

12.8 x 10^{-4} mole ethanol = 12.8 x 10^{-4} x 46.1 g of ethanol

= 5.90 x 10^{-2} g

= 0.06%

Therefore the person would be legally drunk.

(b)

(i) For standard reduction potentials written with the largest positive value at the bottom of the table, any oxidation (reaction right to left) above the half-equation $Pb^{2+}(aq) + 2e^- = Pb(s)$ can reduce Pb^{2+} .

For example, zinc metal and magnesium metal both would reduce Pb^{2+} to Pb(s). In the process, Zn(s) would be oxidised to Zn^{2+} and Mg(s) would be oxidised to Mg^{2+} .

SECTION II: THE ELECTIVES

OXIDATION AND REDUCTION

(ii) The displacement by Mg(s) would be driven by a greater potential because the cell voltage for the combination of half reactions involving Mg(s) and Pb^{2+} (2.23 V) is greater than for the combination involving Zn(s) and Pb^{2+} (0.63 V).

(iii) The overall equation is: Pb^{2+}(aq) + Mg(s) = Pb(s) + Mg^{2+}(aq)

(c) An "oxidant" is the species which causes the oxidation of another species by accepting electrons from it. After the reaction, the other species has been "oxidised". Using (b) (iii) above as an example, the oxidant is Pb^{2+} which causes Mg(s) to be oxidised to Mg^{2+} .

(d)

(i) The oxide layer provides a barrier which protects the magnesium from further reaction with water.

(ii) 1. The oxide of iron does not adhere to the metal. Instead it flakes off, exposing the iron to further corrosion.

2. Galvanising iron by coating it with zinc is one way of protecting it, as the zinc undergoes oxidation more readily than iron.

(e)

(i) The reduction of O_2(g) to H_2O(l) can only occur in conjunction with an oxidation (reaction right to left) which is listed above it in the table of potentials, otherwise a negative E_{cell} would result (-0.17 V) for the overall reaction. As the oxidation of Cl^- to Cl_2(g) is below the reduction of O_2(g), then no reaction will occur.

(ii) Likewise, the reduction of I_2(s) to I^- cannot be brought about by the oxidation of Br^- to Br_2(aq) because the oxidation half reaction lies below the reduction half reaction in the table. (E_{cell} = -0.48 V).

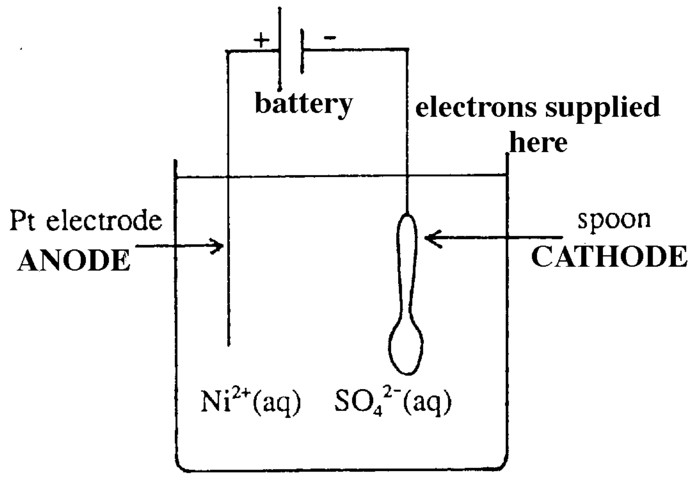
(iii) The reduction of Fe^{3+} (aq) to Fe^{2+} (aq) can be caused by the oxidation of Zn(s) to Zn^{2+} (aq) as the oxidation half equation is above the reduction half equation in the table. This leads to a value of E_{cell}, consistent with a spontaneous reaction. E_{cell} = 0.77 - (-0.76) = +1.53 V

SECTION II: THE ELECTIVES

OXIDATION AND REDUCTION

(f)

(i) The electrolytic cell is shown below.



(ii) The anode reaction is: $2H_2O(l) = O_2(g) + 4H^+(aq) + 4e^-$

(iii) The cathode reaction is: $Ni^{2+} (aq) + 2e^- = Ni(s)$

(iv) The minimum voltage required to plate the spoon is = 1.23 - (-0.23) = 1.46 V **ANS**

SECTION II: THE ELECTIVES

BIOLOGICAL CHEMISTRY

34.

(a)

(i) 1. The molecular formula of Compound I is $C_6H_{12}O_6$.

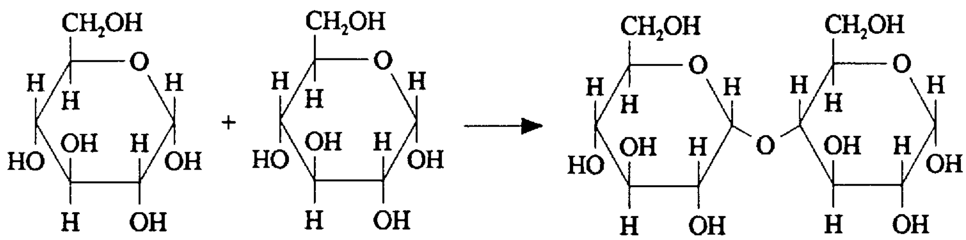
2. The empirical formula of Compound I is CH_2O.

(ii) Compound II is fructose.

(iii) Compound III is maltose.

(iv) Compounds I , II and III all dissolve in water because all these compounds consist of relatively small molecules containing many -OH groups which can hydrogen bond with water and consequently will dissolve in it.

(v) The balanced structural equation for the formation of the disaccharide, Compound III, is



(vi) All of Compounds I, II and III are reducing sugars.

(vii) A chemical reaction to determine whether a carbohydrate is a reducing sugar is:

Warm the carbohydrate with Fehling's solution. Reducing sugars will cause a red precipitate of Cu_2O to form.

(viii) A polysaccharide made from glucose is starch.

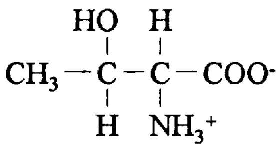
Another polysaccharide made from glucose is cellulose.

SECTION II: THE ELECTIVES

BIOLOGICAL CHEMISTRY

(b)

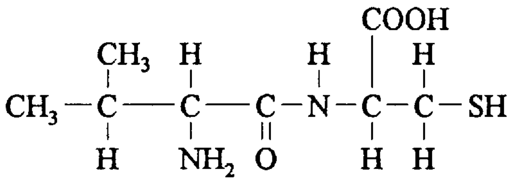
(i) The zwitter ion structure of threonine is shown below.



(ii) Amino acids occur as crystalline solids with relatively high melting temperatures and are soluble in water. These are all characteristics of species having ionic properties.

(iii) The functional groups in valine are -COOH (carboxylic acid) and $-NH_2$ (amine).

(iv) The structure of a dipeptide made from valine and cysteine is shown below.



(c) Denaturation occurs when a protein loses its biological activity as a result of breaking its secondary and tertiary structures. This occurs if the protein is heated to 60°C, experiences a significant change in pH or is subjected to vigorous stirring. The protein in egg white converts to the inactive white solid when the egg is boiled.

(d)

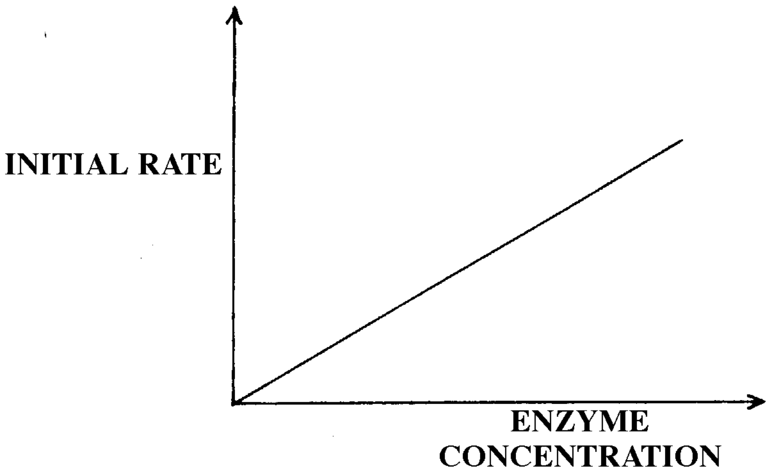
(i) Enzymes belong to the group of biological molecules called proteins.

(ii) Enzymes are proteins which catalyse reactions in cells. They are highly specific in catalysing only one reaction and they are extremely efficient, giving yields of up to 100%.

SECTION II: THE ELECTIVES

BIOLOGICAL CHEMISTRY

(iii) A graph showing the relationship between the initial rate of an enzyme reaction and the enzyme concentration is shown below. It is a linear relationship.



(iv) The following test would distinguish between sucrase and sucrose.
Add sucrose to the solution, and then warm with Fehling's solution. If the substance is sucrase which is an enzyme that splits sucrose into the reducing sugars glucose and fructose, then a red precipitate of Cu_2O forms. If the substance is sucrose, a non-reducing sugar, there would be no reaction with Fehling's solution.

(e)

(i) The overall equation for photosynthesis is:

$6CO_2(g) + 6H_2O(l) + \text{sunlight} = C_6H_{12}O_6(aq) + 6O_2(g)$

(ii) $n(CO_2) = 1500/24.6 = 60.98$ mol

Mass of 1 mole CO_2 = 44.01 g

Mass of CO_2 = 60.98 x 44.01 = 2684 g **ANS**

(iii) Animals usually store glucose in the form of glycogen.

(iv) Oxidation of glucose provides energy for cells to convert ADP to ATP, the energy source for cell functioning.

(v) The differences between the aerobic and anaerobic growth of yeast.
Under either set of conditions, the carbohydrate is firstly converted to pyruvic acid. If the conditions are anaerobic, this is then converted to ethanol and little ATP is produced for cell reproduction. When the conditions are aerobic, the pyruvic acid enters the Krebs cycle, generating much more ATP and providing the energy needed for cell growth.

SECTION II: THE ELECTIVES

CHEMISTRY AND THE ENVIRONMENT

35.
(a)

(i) River A has a high faecal coliform count. This indicates animal activity.

(ii) 1. **Possible reasons for the differences in dissolved oxygen.**
Dissolved oxygen depends on temperature, dissolved salts and biological demand. Assuming that the first two factors are the same for both rivers, then the lower oxygen content of A could be indicative of a larger demand from micro-organisms, especially given the higher coliform count.

2. **Possible reasons for the differences in pH.**
The water in A is acidic while in B it is basic. The lower pH of A could be due to dissolved carbon dioxide, run-off containing acids from soil or microbial activity, or it could be due to industrial effluent. The relatively high pH of B indicates the possibility of dissolved carbonates being present, as these give a basic reaction with water.

(iii) In order to show the presence of micro-organisms, a measured volume of water is drawn through a microbial filter which is then placed on a nutrient agar plate and incubated. Each cell in the water sample could develop into a visible colony.

(iv) A sample of River A water could be neutralised by sodium carbonate (Na_2CO_3) which is soluble and the carbonate ion is a weak base which removes the H^+(aq) ions by forming carbon dioxide and water.

(b)

(i) Hardness is an undesirable characteristic of water for these purposes since solids deposit out of the hard water and physically block the core of radiators and the holes in steam irons.

(ii) Hardness is caused by salts dissolving in the water as it passes through soil.

(iii) Hardness in water can be detected by evaporating of a sample of hard water. This will leave a solid residue. Also, hard water can be detected by difficulty in getting soap to lather.

SECTION II: THE ELECTIVES

CHEMISTRY AND THE ENVIRONMENT

(c)

(i) $n(SO_4^{2-})$ in 1 L = 6.7×10^{-3} mol

$n(SO_4^{2-})$ in 50.0 ml = $6.7 \times 10^{-3} \times 0.0500$ mol

= 3.35×10^{-4} mol

The balanced equation for the reaction is: $Ba^{2+}(aq) + SO_4^{2-}(aq) = BaSO_4(s)$

1 mole $SO_4^{2-}(aq)$ reacts with 1 mole $Ba^{2+}(aq)$ which is derived from 1 mole $BaCl_2(s)$

$n(BaCl_2)$ required = 3.35×10^{-4} mol

1 mole $BaCl_2$ = 208.2 g

mass $BaCl_2$ required = $3.35 \times 10^{-4} \times 208.2 = 6.97 \times 10^{-2}$ g **ANS**

(ii) The sulfate ion is present in rainwater because oxides of sulfur from combustion of fuels form acids by combining with water in the atmosphere. These acids precipitate as "acid rain”.

(d)

(i) The nuclear decay of strontium-90 is described by the equation: ${}^{90}_{38}Sr \rightarrow {}^{90}_{39}Y + {}^{0}_{-1}\beta$

(ii) Strontium and calcium are in the same Group of the Periodic Table and consequently they chemically in similar ways. In particular, they form similar compounds present in milk and bones. Hence, strontium-90 is able to replace calcium in milk and bone tissue.

(iii) The half-life of ${}^{90}Sr$ = 28.1 years 85 years is approximately 3 half-lives.

Amount of ${}^{90}Sr$ remaining = 1/2 x 1/2 x 1/2 x 1.0 g = 0.125 g **ANS**

(iv) β particles are ionising radiation and the resulting ions formed can oxidise biologically active molecules. Possible consequences include cell death or malignancy.

(v) **For safe disposal of strontium-90.**
Strontium carbonate is insoluble and can be precipitated by adding a soluble carbonate to a solution containing the strontium-90. The resulting solid could be collected and stored in stainless steel drums while the radioactive species decayed.

SECTION II: THE ELECTIVES

CHEMISTRY AND THE ENVIRONMENT

(e)

(i) It is important to control the emission of nitrogen oxide gases because nitrogen oxides convert to nitric acid in the atmosphere and precipitate as acid rain which damages plant, aquatic life as well as limestone and metal structures These oxides are also partly responsible for the generation of ozone in photochemical smog.

(ii) **A test for sulfur dioxide.**
Bubble the gas through an acidified solution of potassium permanganate or potassium dichromate. The SO_2 will be oxidised and the permanganate solution will decolourise or the dichromate solution will change from orange to green.

(iii) Mass CO_2 = 600 - 532 = 68 g

% CO_2 = (68/600) x 100 = 11.3% **ANS**

Mass O_2 = 532 - 462 = 70 g

% O_2 = (70/600) x 100 = 11.7% **ANS**

Mass N_2 = 462 g

% N_2 = (462/600) x 100 = 77.0% **ANS**

(iv) 1. Carbon dioxide acts as a heat trap by absorbing heat radiated from the earth's surface and then radiating it back in part to the earth. Thus some of the heat which would otherwise escape into space is retained.

2. Carbon dioxide emissions could be reduced by avoiding the use of fossil fuels. This could be done by using alternative energy sources such as nuclear power, wind power and solar energy.

SECTION II: THE ELECTIVES

CHEMISTRY AND THE ENVIRONMENT

(f)

(i) Nitrogen is an important element for living things because nitrogen atoms are essential components of amino acid molecules from which proteins are made.

(ii) Step A: Plants absorb compounds of nitrogen which are formed from the element by lightning or bacterial action.

(iii) Gas B is NH_3.

END OF NSW HSC CHEMISTRY 1996
SUGGESTED SOLUTIONS

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