NECTA A-Level
CHEMISTRY 2
May 2002

[02/2]
SECTION A

1. (a) What is meant by the following terms?
   (i) Negative catalyst
   (ii) Common ion effect
   (b) Explain the following statements:
   (i) Hydrogen chloride does not obey Henry's law.
   (ii) It is incorrect to refer to concentrated hydrochloric acid as strong hydrochloric acid.
   (iii) On dissolving in water hydrogen chloride (HCl) ionises and dissociates but potassium chloride dissociates only.
   (c) (i) which of the following acids is the strongest and which is the weakest? Give reason(s) for your answer.
   Nitrous acid $HNO_2$ $Ka = 5.1x10^{-4}$
   Sulphurous acid ($H_2SO_3$) $Ka = 1.7x10^{-2}$
   Phosphoric acid ($H_3PO_4$) $Ka = 7.1x10^{-3}$
   (ii) Sodium thiosulphate react with iodine according to the equation
   $2Na_2S_2O_3 + I_2 \rightarrow 2NaI + Na_2S_4O_6$
   Explain whether the iodine molecules are being oxidised or reduced.
   What mass of iodine would be required to react with $30cm^3$ of 0.10M sodium thiosulphate ($Na_2S_2O_3$)?

2. (a) Define the following terms:
   (i) Standard bond dissociation enthalpy
   (ii) Standard enthalpy of atomization
   (iii) Standard state of a substance
   (iv) Standard lattice energy
   (b) the following are mean standard bond enthalpies:
   C = O $\Delta H^o = 743kJ\ mol^{-1}$
   C - H $\Delta H^o = 412kJ\ mol^{-1}$
   C - O $\Delta H^o = 360kJ\ mol^{-1}$
   C - C $\Delta H^o = 348kJ\ mol^{-1}$
   H - O $\Delta H^o = 463kJ\ mol^{-1}$
   Using the above information calculate the standard enthalpy change of the reaction:

$$CH_3COCH_3(g) + HCN(g) \rightarrow CH_3C\begin{matrix}OH\\CN(g)\end{matrix}$$

   (c) For the reaction $CO(g) + NO(g) \rightarrow CO_2(g) + NO(g)$ the amounts of activation energy for the forward and reverse reaction are known to be $32kJmol^{-1}$ and $82.1kJmol^{-1}$ respectively.
   (i) Calculate the heat of reaction
   (ii) Draw the energy profile (ie potential energy) diagram for this system indicating the heat of reaction and the activation energy for forward and backward reaction.

3. (a) Consider the reaction $Mg + Co^{2+} \rightarrow Co + Mg^{2+}$ to determine
   (i) the substance which acts as the reducing agent. Give reason(s)
   (ii) the substance which acts as the oxidising agent. Give reason(s)
   (b) Given the following
   $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ $E^o = 0.34V$
   $Ag^+(aq) + e^- \rightarrow Ag(s)$ $E^o = 0.80V$
   (i) Which is the thermodynamically feasible; the reduction of Silver(I) ion ($Ag^+$) by copper or the reduction of Copper(II) ($Cu^{2+}$) by Silver? Give reason(s) for your answer.
   (ii) Write the two half-reaction equations indicating which half-reaction is

undergoing reduction and which is undergoing oxidation reaction.

(iii) Write the redox equation for the thermodynamically feasible reaction.

(iv) Write the cell diagram for the thermodynamically feasible reaction

(v) Determine the standard cell e.m.f.

4. (a) Explain the meaning of the following terms:

(i) Rate-determining step

(ii) Intermediate product

(iii) Elementary reaction

(iv) Reaction rate.

(b) One of the dozens of reactions that may occur in a single ridden area is the linked oxidation of carbon monoxide and nitric oxide.

$$CO + NO + O_2 \rightarrow CO_2 + NO_2$$

One suggested mechanism for this reaction involves the unstable molecular fragment HO as a catalyst;

(i) Verify that these steps add to give the correct net reaction.

(ii) Identify the intermediates in the mechanism

(iii) Tell why HO is considered to be a catalyst in this reaction path way.

(c) The following results were obtained in a reaction between A and B at 293K.

| Run | Concentration/mol $dm^{-3}$ | | Initial Rate |
|---|---|---|---|
| | A | B | Mol $dm^{-3}$ $s^{-1}$ |
| a | 0.50 | 1.0 | 2.0 |
| b | 0.50 | 2.0 | 8.0 |
| c | 0.50 | 3.0 | 18.0 |
| d | 1.0 | 3.0 | 36.0 |
| e | 2.0 | 3.0 | 72.0 |

Determine

(i) the order of the reaction with respect to A and with respect to B

(ii) the overall order of the reaction

(iii) the value of the rate constant and state its units if any

SECTION B

5. (a) Explain why

(i) aqueous Iron (III) chloride liberates carbondioxide form sodium carbonate

(ii) Sulphur dioxide ($SO_2$) has a low boiling point temperature but compounds containing sulphate ion ($SO_4^{2-}$) do not have.

(iii) Potassium ion ($K^+$) is smaller than the chloride ion ($Cl^-$) even though they have the same number of electrons.

(iv) Concentrated sulphuric acid ($H_2SO_4$) should not be used to dry hydrogen sulphide ($H_2S$).

(v) Iodine is sparingly soluble in water but readily soluble in a concentrated solution of potassium iodide.

(b) Explain the meaning of the term "diagonal relationship" giving at least three examples of related elements and the way they are related.

6. (a) It is often said that the element at the top of each group is not typical of the rest of the group in periodic table. By choosing four suitable examples of elements and reactions, illustrate briefly this comment.

(b) Below is a representation of two periods of the periodic table

| GROUP | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|
| | Li | Be | B | C | N | O | F |
| | Na | Mg | Al | Si | P | S | Cl |

Indicate by the symbol which of these elements you consider to be

(i) the most reactive non-metal

(ii) the most reactive metal

(iii) the one with the smallest atom

(iv) the one which forms the largest anion

(v) in the same group as an element of atomic number 31.

(c) What is meant by the term "metallic bonding"?

7. (a) Summarize the trends of the nitrogen and beryllium groups with respect to:
   (i) first ionization potential
   (ii) the polar character of hydrides
   (iii) acid-base character of oxides
   Comment on the fact that the first element in a group appear to behave somehow different from the rest in relation to the two trends above.

(b) Compare and comment on properties of the following pairs of compounds:
   (i) $CO_2$ and $SiO_2$
   (ii) $CCl_4$ and $SiCl_4$

(c) Explain what happens and show all the chemical reactions that take place when
   (i) hydrogen sulphide is passed into an aqueous solution of acidified potassium permanganate
   (ii) hydrogen peroxide is added to a solution of ferrous sulphate followed by potassium hexacyanoferrate (II) or potassium ferrocyanide solution
   (iii) potassium iodide solution is added to a copper (II) sulphate solution, followed by sodium thiosulphate solution
   (iv) sulphur dioxide in water is passed though acidified potassium permangaget solution

SECTION C

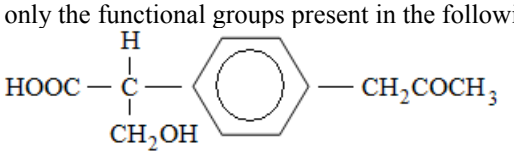
8. (a) What do you understand by
   (i) isomerism
   (ii) Functional groups
   (iii) Homologous series
   (iv) Catenation?

(b) Quantitative analysis of compound W gave the following results:
   C = 49.3% H = 9.6% N = 19.2% O = 21.96%
A solution of 0.1825g of W in 10g of water began to freeze at 0.456°C. When W was treated with bromine and caustic potash under suitable conditions it gave compound Z, containing C = 53.3% H = 15.6% N = 31.1%
   (i) determine the empirical formulae of W and Z
   (ii) determine the molecular formula of W
   (iii) Suggest the structural formula of W
   (iv) Use the reaction: $W \xrightarrow{\text{Caustic potash}} Z$ to show how the structure you have suggested in (iii) was arrived at.

9. (a) Show how the following conversions may be achieved. Experimental details of the conversions are not required.
   (i) $CH_3CH_2OH$ to $CH_3CH_2COOH$
   (ii) $CH_3CH_2COOH$ to $CH_3COCH_3$
   (iii) $CH_3COCH_3$ to $CH_3CHBrCH_2Br$
   (iv) $HC{\equiv}CH$ to $CH_3COCH_3$

(b) (i) Arrange the following compounds in order of decreasing basic strength: Ammonia, aniline, ethylamine, triethylamine and diethylamine
   (ii) Arrange the following compounds in order of increasing acidic strength $Cl_2CHCOOH$, $CH_3COOH$, $CH_2ClCOOH$, $CCl_3COOH$

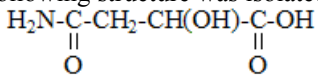
(c) By considering only the functional groups present in the following compound:



predict the products when this compound reacts with:
   (i) Acidified $KMnO_4$ at 60 – 80°C
   (ii) Hydrogen gas and nickel at 140°C
   (iii) Phosphorous pentachloride
   (iv) A warm mixture of iodine and sodium hydroxide

(v) 2,4-dinitrophenylhydrazine

10. (a) A compound with the following structure was isolated from extracts of a certain plant:



Using your knowledge of organic chemistry, predict what might take place when this compound is treated with:

(i) Potassium dichromate
(ii) Ethanol
(iii) Phosphorous pentachloride
(iv) $LiAlH_4$

(b) Two isomeric hydrocarbons P and Q have molecular formula of $C_9H_{12}$. On oxidation, P gives a monocarboxylic acid which, when treated with sodalime, yields benzene. Q is oxidised to give a tricarboxylic acid; this tricarboxylic acid can then undergo an electrophilic nitration reaction to give two mononitro derivatives. Deduce the structural formula of P and Q and explain the reactions described above.