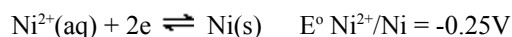


NECTA A-Level  
CHEMISTRY 2  
May 2003

[03/2]  
SECTION A

1.
  - (a)
    - (i) Define the term dynamic equilibrium
    - (ii) State the equilibrium law
  - (b) given the following system at equilibrium:  
 $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) \quad \Delta H = -188.0 \text{ kJ mol}^{-1}$   
Predict the change of the concentration of  $\text{SO}_3$  if
    - (i) the pressure of the system is increased
    - (ii) a noble gas is added such that the pressure of the system increases but no volume changes occur
    - (iii) more  $\text{SO}_3$  is added to the system
    - (iv) the temperature of the system is increased
  - (c) Consider the decomposition of phosphorous pentachloride:  
 $\text{PCl}_5(\text{g}) \rightleftharpoons \text{PCl}_3(\text{g}) + \text{Cl}_2(\text{g})$   
Derive an expression which relates  $K_c$  and  $K_p$  for the above equilibrium where  $K_c$  and  $K_p$  are the equilibrium constants in terms of concentration and pressure respectively.
  - (d) At  $500^\circ\text{C}$ , the reaction between nitrogen and hydrogen to form ammonia has  $K_c = 8.0 \times 10^{-2}$   
Calculate its  $K_p$  value.
2.
  - (a) State Hess's Law of constant heat summation.
  - (b) By using Hess's Law, calculate the standard enthalpy of formation of methane ( $\text{CH}_4$ ) given that its standard enthalpy of combustion is  $895 \text{ kJ/mol}$ , the standard enthalpy of combustion of carbon graphite is  $395.5 \text{ kJ/mol}$  and the enthalpy of formation of water is  $-285.9 \text{ kJ/mol}$ .
  - (c) When  $1.0 \text{ g}$  of anhydrous copper (II) sulphate ( $\text{CuSO}_4$ ) was dissolved in a large amount of water,  $0.418 \text{ kJ}$  of heat were liberated. When  $5.0 \text{ g}$  of copper (II) sulphate pentahydrated crystalline salt were dissolved in a large amount of water,  $0.230 \text{ kJ}$  of heat were absorbed. From this data calculate the heat change,  $Z$  of the following reaction:  
$$\text{CuSO}_4(\text{s}) + 5\text{H}_2\text{O}(\text{l}) \rightarrow \text{CuSO}_4 \cdot 5\text{H}_2\text{O} \quad \Delta H = Z \text{ kJ mol}^{-1}$$
3. With the aid of chemical equations explain the following:
  - (a) hard water becomes soft when washing soda ( $\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$ ) is added.
  - (b) Iodine is sparingly soluble in water but dissolves readily in the presence of iodide ions.
  - (c) lead (IV) oxide forms a bright yellow liquid when dissolved in excess ice cold concentrated hydrochloric acid.
  - (d) Effervescence of a colourless gas is obtained when sodium hydrogen carbonate is added to copper (II) sulphate solution.
  - (e) Mercury (II) iodide is readily soluble in potassium iodide solution but not in water
  - (f) The pink solution of cobalt (II) chloride turns blue when concentrated hydrochloric acid is added.
  - (g) When water is sprayed into a dry mixture of sulphur dioxide and hydrogen sulphide, a yellow solid is formed
  - (h) An aqueous solution of aluminum chloride is acidic to litmus
  - (i) Concentrated hydrochloric acid prevents precipitation of copper (II) sulphide from copper (II) salt aqueous solutions
  - (j) Effervescence of a colourless gas is obtained when ammonium chloride solution is added to a warm aqueous solution of sodium nitrite.
4.
  - (a) Explain the meaning of the following terms:
    - (i) Electrochemical series
    - (ii) Electrochemical equivalent
    - (iii) Redox series
    - (iv) Redox reaction
  - (b) Given the following:  
 $\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightleftharpoons \text{Zn}(\text{s}) \quad E^\circ \text{ Zn}^{2+}/\text{Zn} = -0.76 \text{ V}$



- (i) Which is the feasible reaction, the reduction of  $\text{Ni}^{2+}$  by Zinc or the reduction of  $\text{Zn}^{2+}$  by nickel? Give reasons
  - (ii) Write a balanced redox equation for the feasible reaction
  - (iii) Determine the cell diagram
  - (iv) Calculate the e.m.f. of the cell
- (c) Sodium chlorate (I) is converted by heat to sodium chlorate (V) and sodium chloride according to the equation  $3\text{NaOCl} \xrightarrow{\Delta} \text{NaClO}_3 + 2\text{NaCl}$
- Using oxidation numbers show which particle(s) in the equation have undergone
- (i) oxidation
  - (ii) reduction

## SECTION B

5.
  - (a) Give the meaning of volumetric analysis
  - (b) Differentiate between
    - (i) molar solution and normal solution
    - (ii) standard solution and primary standard solution
  - (c) What is the oxidation number of chlorine in the following anions?
    - (i)  $\text{ClO}^-$
    - (ii)  $\text{ClO}_3^-$
  - (d) A standard solution is prepared by dissolving 1.185 grams of potassium dichromate (VI) ( $\text{K}_2\text{Cr}_2\text{O}_7$ ) and making up to  $250\text{cm}^3$  of solution. This solution is used to find the concentration of a sodium thiosulphate ( $\text{Na}_2\text{S}_2\text{O}_3$ ) solution. A  $25.00\text{cm}^3$  portion of the potassium dichromate (VI) solution was acidified and added to an excess of potassium iodide (KI) to liberate iodine according to the following equation:
 
$$\text{Cr}_2\text{O}_7^{2-} + 6\text{I}^- + 14\text{H}^+ \rightarrow 3\text{I}_2 + 2\text{Cr}^{3+} + 7\text{H}_2\text{O}$$

The liberated iodine may be estimated by using sodium thiosulphate solution which is oxidized as follows:  $\text{I}_2 + 2\text{S}_2\text{O}_3^{2-} \rightarrow \text{S}_4\text{O}_6^{2-} + 2\text{I}^-$

When the solution was titrated against sodium thiosulphate solution,  $17.50\text{cm}^3$  of sodium thiosulphate were required. Calculate

    - (i) the concentration in mole per litre of potassium dichromate solution
    - (ii) the concentration in moles per litre of sodium thiosulphate solution
    - (iii) the number of electrons which were accepted by potassium dichromate (VI) during the reaction.

## SECTION C

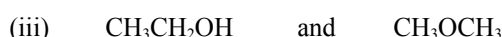
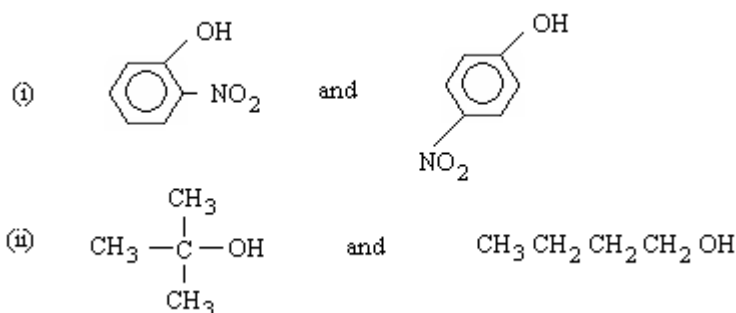
6.
  - (a) Explain the following:
    - (i) Aluminum is more metallic than boron although both are found in group III of the periodic table
    - (ii) It is not possible to prepare hydrogen iodide by the action of concentrated sulphuric acid on potassium iodide
    - (iii) Simple salts of copper (I) are not known
    - (iv) Whereas carbon forms a limitless number of stable hydrides, this tendency decreases rapidly with the increase of atomic numbers down group four of the periodic table
    - (v) some of the compounds of lithium have a partially covalent character
  - (b) The elements of group I of the periodic table form a well marked family of closely related elements. By choosing four chemical properties briefly justify this comment.
7.
  - (a) What do you understand by the following terms?
    - (i) Heat of reaction
    - (ii) Thermochemical equations
  - (b) Given the following reactions:
 

$\text{Cd}(\text{s}) \rightarrow \text{Cd}(\text{g})$	$\Delta H_1^\circ$
$\text{Cd}(\text{g}) \rightarrow \text{Cd}^{2+}(\text{g}) + 2\text{e}^-$	$\Delta H_2^\circ$
$\text{I}_2(\text{s}) \rightarrow \text{I}_2(\text{g})$	$\Delta H_3^\circ$
$\text{I}_2(\text{g}) \rightarrow 2\text{I}(\text{g})$	$\Delta H_4^\circ$
$\text{I}(\text{g}) + \text{e}^- \rightarrow \text{I}^-(\text{g})$	$\Delta H_5^\circ$
$\text{Cd}(\text{s}) + \text{I}_2(\text{s}) \rightarrow \text{CdI}_2(\text{g})$	$\Delta H_6^\circ$
$\text{Cd}^{2+}(\text{g}) + 2\text{I}^-(\text{g}) \rightarrow \text{CdI}_2(\text{s})$	$\Delta H_7^\circ$

- (i) What do the symbols  $\Delta H_1^\circ$  to  $\Delta H_7^\circ$  above refer to?
- (ii) What is the sign for the enthalpy change corresponding to the symbol  $\Delta H_5^\circ$  above?
- (iv) Define the standard enthalpy change corresponding to the following symbols  $\Delta H_1^\circ$ ,  $\Delta H_5^\circ$ ,  $\Delta H_6^\circ$  and  $\Delta H_7^\circ$  indicated above.
- (v) Calculate the value of  $\Delta H_7^\circ$  given the following values  
 $\Delta H_1^\circ = +113 \text{ kJ mol}^{-1}$   
 $\Delta H_2^\circ = +2490 \text{ kJ mol}^{-1}$   
 $\Delta H_3^\circ = +19.4 \text{ kJ mol}^{-1}$   
 $\Delta H_4^\circ = +151 \text{ kJ mol}^{-1}$   
 $\Delta H_5^\circ = -314 \text{ kJ mol}^{-1}$   
 $\Delta H_6^\circ = -2014 \text{ kJ mol}^{-1}$

## SECTION C

8. (a) The members of the following pairs of isomeric compound have different melting points or boiling points. Indicate which member has the higher value and suggest reasons for the difference.



- (b) It is deduced from the mass spectrum that a pure organic liquid X has a relative molecular mass of 58. From combustion analysis its empirical formula is  $\text{C}_3\text{H}_6\text{O}$

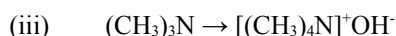
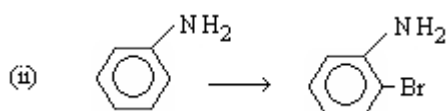
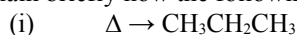
- (i) What is the molecular formula of X?
- (ii) Suggest two possible structures of X

- (c) Liquid X in 8.(b) was then subjected to the following tests:

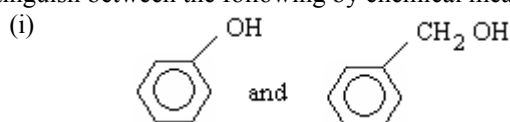
TEST	REAGENT	OBSERVATION
A	Sodium metal	No reaction
B	Bromine water	No reaction
C	2,4-dinitrophenylhydrazine	Orange precipitate positive result
D	Ammonical silver nitrate Tollens' reagent	No reaction

- (i) What can be said about the structure of liquid X from
  - test A alone
  - test B alone
  - test D alone
  - test C and D taken together?
- (ii) Identify the structure of liquid X.

9. (a) Explain briefly how the following conversions can be affected:

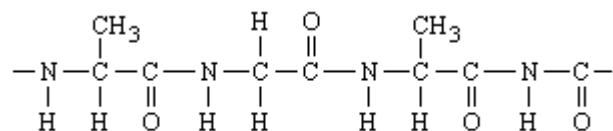


- (b) Distinguish between the following by chemical means:



- (ii)  $\text{CHCl}_3$  and  $\text{CH}_3\text{CCl}_3$
- (iii)  $(\text{CH}_3)_2\text{CO}$  and  $\text{CH}_3\text{CH}_2\text{CHO}$
- (c) Explain the following:
  - (i) Phenol is more acidic than ethanol
  - (ii) Trichloroethanoic acid is a stronger acid than ethanoic acid
  - (iii) Aniline (phenylamine) is a weaker base than ethylamine

10. (a) Give the products when ethyl alcohol reacts with concentrated sulphuric acid under the following conditions:
- (i)  $180^\circ\text{C}$
  - (ii)  $140^\circ\text{C}$
- (b) The following is part of a protein chain.



Draw the structure of two amino acids obtained on hydrolysis of this protein.

- (c) 1.1g of a compound containing carbon, hydrogen and oxygen gave on combustion 1.173g of  $\text{CO}_2$  and 0.240g  $\text{H}_2\text{O}$ . 1.125g of the compound in 125g of water gave a solution freezing at  $-0.186^\circ\text{C}$ . Calculate the molecular mass of the compound and write its molecular formula.  $\{K_f = 1.86^\circ\text{Cmol}^{-1} \text{ kg}^{-1}\}$