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:
$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g) \quad \Delta H = -188.0 kJmol^{-1}$
Predict the change of the concentration of 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 SO_3 is added to the system
(iv) the temperature of the system is increased
(c) Consider the decomposition of phosphorous pentachloride:
$PCl_5(g) \rightleftharpoons PCl_3(g) + Cl_2(g)$
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°C, the reaction between nitrogen and hydrogen to form ammonia has $K_c = 8.0x10^{-2}$ Calculate its K_p value.

2. (a) State Hess's Law of constant hear summation.
(b) By using Hess's Law, calculate the standard enthalpy of formation of methane (CH_4) given that its standard enthalpy of combustion is 895kJ/mol, the standard enthalpy of combustion of carbon graphite is 395.5kJ/mol and the enthalpy of formation of water is -285.9kJ/mol.
(c) When 1.0g of anhydrous copper (II) sulphate ($CuSO_4$) was dissolved in a large amount of water, 0.418kJ of heat were liberated. When 5.0g of copper (II) sulphate pentahydrated crystalline salt were dissolved in a large amount of water, 0.230kJ of heat were absorbed. From this data calculate the heat change, Z of the following reaction:
$CuSO_4(s) + 5H_2O(l) \rightarrow CuSO_4 \cdot 5H_2O \qquad \Delta H = Z\ kJmol^{-1}$

3. With the aid of chemical equations explain the following:
(a) hard water becomes soft when washing soda ($Na_2CO_3 \cdot 10H_2O$) 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:
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s) \quad E^o\ Zn^{2+}/Zn = -0.76V$

$Ni^{2+}(aq) + 2e \rightleftharpoons Ni(s)$ $E^o\ Ni^{2+}/Ni = -0.25V$

(i) Which is the feasible reaction, the reduction of Ni^{2+} by Zinc or the reduction of 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 $3NaOCl \xrightarrow{\Delta} NaClO_3 + 2NaCl$

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) ClO^- (ii) ClO_3^-

(d) A standard solution is prepared by dissolving 1.185 grams of potassium dichromate (VI) ($K_2Cr_2O_7$) and making up to $250cm^3$ of solution. This solution is used to find the concentration of a sodium thiosulphate ($Na_2S_2O_3$) solution. A $25.00cm^3$ 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:

$Cr_2O_7^{2-} + 6I^- + 14H^+ \rightarrow 3I_2 + 2Cr^{3+} + 7H_2O$

The liberated iodine may be estimated by using sodium thiosulphate solution which is oxidized as follows: $I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$

When the solution was titrated against sodium thiosulphate solution, $17.50cm^3$ 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:

$Cd(s) \rightarrow Cd(g)$	ΔH_1^o
$Cd(g) \rightarrow Cd^{2+}(g) + 2e^-$	ΔH_2^o
$I_2(s) \rightarrow I_2(g)$	ΔH_3^o
$I_2(g) \rightarrow 2I(g)$	ΔH_4^o
$I(g) + e^- \rightarrow I^-(g)$	ΔH_5^o
$Cd(s) + I_2(s) \rightarrow CdI_2(g)$	ΔH_6^o
$Cd^{2+}(g) + 2I^-(g) \rightarrow CdI_2(s)$	ΔH_7^o

(i) What do the symbols ΔH_1^o to ΔH_7^o above refer to?

(ii) What is the sign for the enthalpy change corresponding to the symbol ΔH_5^o above?

(iv) Define the standard enthalpy change corresponding to the following symbols ΔH_1^o, ΔH_5^o, ΔH_6^o and ΔH_7^o indicated above.

(v) Calculate the value of ΔH_7^o given the following values

$\Delta H_1^o = +113 kJmol^-$

$\Delta H_2^o = +2490 kJmol^-$

$\Delta H_3^o = +19.4 kJmol^-$

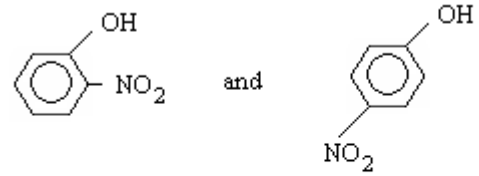
$\Delta H_4^o = +151 kJmol^-$

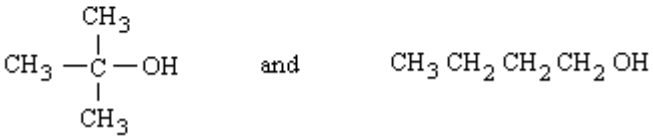
$\Delta H_5^o = -314 kJmol^-$

$\Delta H_6^o = -2014 kJmol^-$

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.

(i) 

(ii) 

(iii) CH_3CH_2OH and CH_3OCH_3

(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 C_3H_6O

(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:

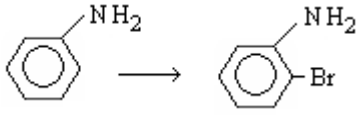
TEST	REAGENT	OBSERVATION
A	Sodium metal	No reaction
B	Bromine water	No reaction
C	2,4-dinitrophenylhydiazine	Orange precipitate positive result
D	Ammonical silver nitrate Tollens' reagent	No reaction

(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.

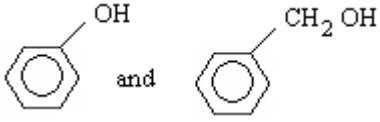
9. (a) Explain briefly how the following conversions can be affected:

(i) $\Delta \rightarrow CH_3CH_2CH_3$

(ii) 

(iii) $(CH_3)_3N \rightarrow [(CH_3)_4N]^+OH^-$

(b) Distinguish between the following by chemical means:

(i) 

(ii) $CHCl_3$ and CH_3CCl_3

(iii) $(CH_3)_2CO$ and CH_3CH_2CHO

(c) Explain the following:

(i) Phenol is more acidic than ethanol

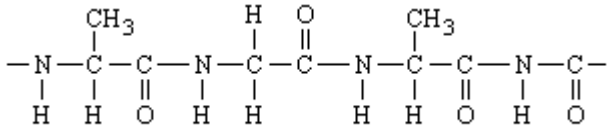
(ii) Trichloroethanoic acid is a stronger acid than ethanoic acid

(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°C (ii) 140°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 CO_2 and 0.240g H_2O. 1.125g of the compound in 125g of water gave a solution freezing at -0.186°C. Calculate the molecular mass of the compound and write its molecular formula. $\{K_f = 1.86^oCmol^{-1}\ kg^{-1}\}$