

NECTA A-Level
CHEMISTRY 1
May 2003

[03/1]
SECTION A

1. (a) State
- (i) Aufbau principle
 - (ii) Hund's rule of maximum multiplicity
 - (iii) the uncertainty principle
- (b) (i) What is an atomic spectrum?
- (ii) How does an atomic spectrum differ from a continuous spectrum?
- (c) The wave length of the lines in the Balmer series of the hydrogen spectrum is given by the expression $1/\lambda = R_H(1/2^2 - 1/n^2)$ where R_H is a constant and n is an integer greater than 2.
- (i) Draw an energy level diagram to show the origin of the **first** and **third** lines in the Balmer series.
 - (ii) Calculate the wavelength of the first line in 1.(c)(i) above.
2. (a) The equilibrium constants for the synthesis of hydrogen chloride, hydrogen bromide and hydrogen iodide are given below:
- $$\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightleftharpoons 2\text{HCl}(\text{g}), K_c = 10^{17}$$
- $$\text{H}_2(\text{g}) + \text{Br}_2(\text{g}) \rightleftharpoons 2\text{HBr}(\text{g}), K_c = 10^9$$
- $$\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g}), K_c = 10$$
- (i) What do the values of K_c tell you about the extent of each reaction?
 - (ii) Which of these reactions would you regard as a complete conversion?
 - (iii) Predict the effect of increasing pressure on the above equilibria.
- (b) The equilibrium constant, K_c for the reaction
- $$2\text{HI}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{I}_2(\text{g})$$
- is 0.02 at 400°C
- If 2 moles of hydrogen and 1 mole of iodine were mixed together in a 1.0dm³ vessel at 400°C how many moles of HI, H₂ and I₂ would be present at equilibrium?
3. (a) Define
- (i) molarity
 - (ii) molality
- (b) Calculate the molarity and molality of a concentrated nitric acid having a density of 1.4g/cm³ containing 75% nitric acid by mass.
4. The Mogul oil company is disturbed by the presence of impurities M in its four star petrol. One dm³ of petrol contains 5g of M. In the efforts to reduce the concentration of M in the petrol, Mogul have discovered the secret of extracting M from the petrol by using solvent S. The partition coefficient of M between petrol and S is 0.01.
- (a) What is the meaning of the term partition coefficient?
 - (b) What are the conditions necessary for the partition coefficient of a solute between the two given solvent to remain constant?
 - (c) Explain the principle of solvent extraction
 - (d) Calculate the total mass of M removed from one dm³ of petrol using one portion of 100cm³ of solvent S. In the other case use two 50cm³ portions of solvent S.
 - (e) What can you conclude from the results of extraction obtained in 4(d) above?
5. (a) Give reasons for the following observations:
- (i) The boiling points of water, ethanol and ethoxyethane (diethylether) are in the reverse order of their relative molecular masses unlike those of their analogous sulphur compounds, H₂S, C₂H₅SH and C₂H₅SC₂H₅.
 - (ii) BF₃ is non-polar but NF₃ is polar
 - (iii) Aluminum fluoride has a much higher melting point than aluminum chloride.
- (b) X, Y and Z represent elements of atomic numbers 9, 19 and 34
- (i) Write the electronic configuration of X, Y and Z
 - (ii) Predict the type of bonding which you would expect to occur

- between X and Y, X and Z, and Y and Z.
- (iii) Predict giving reasons for the relative volatility, electrical conductance and solubility in water of the compounds formed between X and Y compared to that formed between X and Z.
6. (a) Using the kinetic theory gas equation, $pv = \frac{1}{3} mnc^2$ deduce
 (i) the gas law equation, $pv = nRT$
 (ii) Charles's law equation, $v \propto t$ (at constant pressure)
- (b) (i) Why do real gasses deviate from the ideal gas behavior?
 (ii) At what conditions does a real gas obey the ideal gas equation?
- (c) The Van der Waals equation $(p + a/v^2)(v - b) = RT$, where a and b are constants, is used to describe the behavior of real gases. What is the significance of the terms a/v^2 and b in this equation?
- (d) A quantity of 2.4g of a compound fills 934cm^3 as a vapour at 298K and 740mmHg. If it contains 37.21% carbon, 7.8% hydrogen, and 55% chlorine what is its molecular formula?

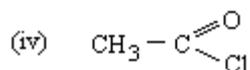
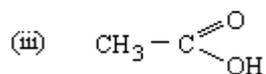
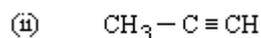
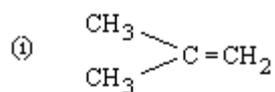
SECTION B

7. (a) Explain the following observations:
 (i) PCl_5 is more reactive than PCl_3
 (ii) AlCl_3 is covalent while AlF_3 is ionic
 (iii) Halogens are generally coloured
- (b) Give an account for the following:
 (i) Alkali earth metals have greater tendency to form complexes than alkali metals.
 (ii) Magnesium does not impart any colour to the flame while calcium in the same group does
 (iii) Melting and boiling points of alkaline earth metals are higher than those of alkali metals.
8. (a) (i) Aluminum and magnesium are both found in period three of the periodic table but the first ionization energy of aluminum is smaller than that of magnesium although aluminum is towards the right of period three. Explain.
 (ii) What is the effect of hydrogen bonding on the boiling point and solubility of a compound?
 (iii) Account for the steady decrease of atomic size of transition metals from scandium to zinc.
- (b) With the help of balanced equations what would be the products of
 (i) dissolving the ionic hydrides of the elements of period three in water?
 (ii) dissolving covalent hydrides of group seven in water?
 (iii) heating transition metal hydrides?
9. (a) With reference to the elements of period 3 of the periodic table give an example of an element which forms
 (i) a basic oxide
 (ii) an acidic oxide
 (iii) an amphoteric oxide
 (iv) solid oxide insoluble in water and the solid consists of a giant molecular lattice.
- (b) (i) explain why hydrogen chloride can conveniently be prepared by warming sodium chloride with concentrated sulphuric acid while a similar method cannot be used for the preparation of hydrogen iodide
 (ii) What is inert pair effect?
- (c) Arrange the following hydrogen halides HF, HCl, HBr and HI in order of
 (i) decreasing thermal stability
 (ii) increasing acidity
10. (a) Define the following
 (i) An oxidant

- (ii) A reduction reaction
 (iii) A disproportionation reaction
- (b) Show whether the underlined atom is oxidized, reduced, disproportionated or remains unchanged.
- (i) $\underline{\text{Pb}}\text{Cl}_2(\text{s}) + \text{Cl}_2(\text{g}) \rightarrow \text{PbCl}_4(\text{s})$
 (ii) $\underline{\text{Na}}\text{OH}(\text{aq}) + \text{HCl}(\text{aq}) \rightarrow \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
 (iii) $2\underline{\text{I}}\text{O}_3^-(\text{aq}) + 5\text{HSO}_3^-(\text{aq}) \rightarrow \underline{\text{I}}_2(\text{s}) + 5\text{SO}_4^{2-}(\text{aq}) + 3\text{H}^+(\text{aq}) + \text{H}_2\text{O}(\text{l})$
 (iv) $\text{Cu}(\text{s}) + 1/2\underline{\text{O}}_2(\text{g}) \rightarrow \text{CuO}(\text{s})$
 (v) $3\underline{\text{Cl}}_2(\text{g}) + 6\text{NaOH}(\text{aq}) \rightarrow 5\underline{\text{NaCl}}(\text{aq}) + \underline{\text{NaClO}}_3(\text{aq}) + \text{H}_2\text{O}(\text{l})$
- (c) Complete and balance the following redox reactions:
- (i) $\text{MnO}_4^-(\text{aq}) + \text{Fe}^{2+}(\text{aq}) + \text{H}^+(\text{aq}) \rightarrow$
 (ii) $\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + \text{Fe}^{2+}(\text{aq}) + \text{H}^+(\text{aq}) \rightarrow$

SECTION C

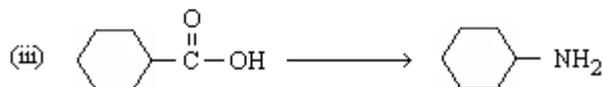
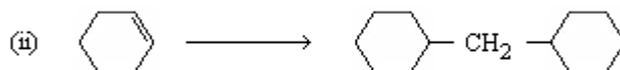
11. (a) Four different bottles contain the following liquids:



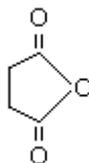
If the bottles were not labeled, give a simple chemical tests which you would use to identify the liquids in the bottles.

- (b) State how you would distinguish chemically hex-1-ene from hex-1-yne
 (c) 10cm^3 of a gaseous hydrocarbon X required 45cm^3 of oxygen for complete combustion. X reacts with one mole of bromine gas to form a brominated hydrocarbon compound of relative molecular mass 202.02 which contains 79.2% bromine. What is the structural formula of X?

12. (a) Show how the following conversions can be carried out under the given restrictions.



- (b) Succinic anhydride with the structure

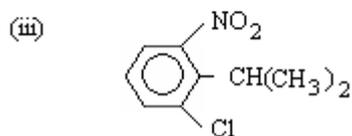
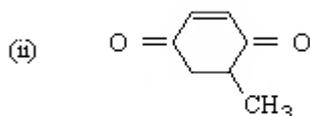
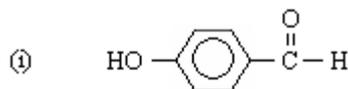


can react with two moles of ammonia. Predict the structure of the product of this reaction.

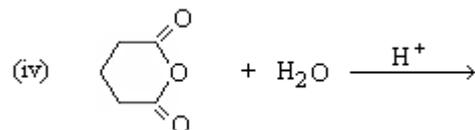
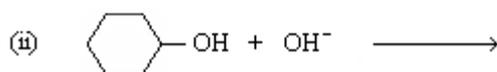
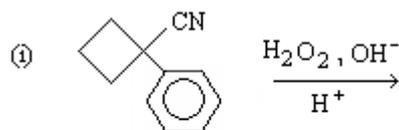
13. (a) Write structures for
- 3-methylbutanenitrite
 - cyclohexylhexanoate
 - 4-phenyl-7-cycloheptylheptanoic acid
 - trimethylammonium chloride
 - 2-hydroxypropanamide

(b) A mixture of acetone and diethyl oxalate [$\text{CH}_3\text{CH}_2\text{O}_2\text{C}-\text{CO}_2\text{CH}_2\text{CH}_3$] is added to a mixture of sodium ethoxide in ethanol. After the reaction is completed, the mixture was treated with cold, dilute HCl. A condensation product was isolated from the mixture in 60% yield. What is the product?

14. (a) Write down the IUPAC names of the following structures:



5. Complete the following equations:



- (c) Arrange, with explanations, the following compounds according to the order of increasing acidity.

$\text{CH}_3\text{CHClCH}_2\text{COOH}$, $\text{CH}_2\text{ClCH}_2\text{CH}_2\text{COOH}$, $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$ and $\text{CH}_3\text{CH}_2\text{CHClCOOH}$