



FACULTY OF SCIENCE

DEPARTMENT OF APPLIED CHEMISTRY
NATIONAL DIPLOMA: ANALYTICAL CHEMISTRY EXTENDED

MODULE CET1CY1
 CHEMISTRY 1CY1

CAMPUS DFC

DECEMBER EXAMINATION

DATE: 03/12/2014

SESSION: 08:00 –11:00

ASSESSOR

DR K PILLAY

INTERNAL MODERATOR

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DURATION 3 HOURS

MARKS 150

NUMBER OF PAGES: 5 PAGES AND 1 ANNEXURE

INSTRUCTIONS: ANSWER ALL QUESTIONS
CALCULATORS ARE PERMITTED (ONLY ONE PER STUDENT)
THE QUESTION PAPER MUST BE HANDED IN WITH THE ANSWER SHEET
PLEASE HAND IN THE QUESTION PAPER.

REQUIREMENTS: ANSWER SCRIPTS.

INSTRUCTIONS TO CANDIDATES:

1. PLEASE ANSWER ALL THE QUESTIONS.
2. AVOGADRO'S NUMBER = $6,022 \times 10^{23}$

QUESTION 1

- 1.1 A sample containing only boron and fluorine was decomposed yielding 4,75 mg of boron and 17,5 mL fluorine (density = 1,43 g/L). What is the empirical formula of the sample compound? (7)
- 1.2 Nitrobenzene, $C_6H_5NO_2$, an important raw material for the dye industry, is prepared from benzene, C_6H_6 and nitric acid, HNO_3 :
- $$C_6H_6(l) + HNO_3(l) \rightarrow C_6H_5NO_2(l) + H_2O(l)$$
- 1.2.1 When 21,6 g of benzene and 15,0 g of HNO_3 are used, what is the theoretical yield of nitrobenzene? (6)
- 1.2.2 If 20,0 g of nitrobenzene was recovered, what was the percentage yield? (2)
- [15]**

QUESTION 2

- 2.1 Iron(III) chloride can be prepared by reacting iron metal with chlorine.
- 2.1.1 Write a balanced chemical equation for the reaction. (4)
- 2.1.2 How many grams of iron are required to produce enough iron(III) chloride to make 3,00 L of aqueous solution containing 9,00% iron(III) chloride by mass? The density of the solution is 1,067 g/mL. (6)
- 2.2 How many millilitres of 0,150 M sulphuric acid are required to react with 8,20 g of sodium hydrogen carbonate? (5)
- 2.3 Identify the conjugate acid–base pairs in the following acid-base equilibrium reactions: (4)
- 2.3.1 $HCOOH(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + HCOO^-(aq)$
- 2.3.2 $HCO_3^-(aq) + H_2S(g) \rightleftharpoons H_2CO_3(aq) + HS^-(aq)$

QUESTION 2 (CONTINUED)

- 2.4 Barium carbonate is the source of barium compounds. It is produced in an aqueous precipitation reaction between barium sulphide and sodium carbonate.
- 2.4.1 Give the balanced molecular and net ionic equation for the precipitation reaction. (4)
- 2.4.2 Identify the spectator ions. (2)
- 2.4.3 A solution containing 33,9 g of barium sulphide and 21,2 g of sodium carbonate is allowed to react completely. How many grams of precipitate are produced? (4)
- 2.5 The following reaction occurs in **basic medium**:
- $$\text{H}_2\text{O}_2(\text{aq}) + \text{Cl}_2\text{O}_7(\text{aq}) \rightarrow \text{ClO}_2^-(\text{aq}) + \text{O}_2(\text{g})$$
- 2.5.1 Identify the oxidizing and reducing agent in the above reaction. (2)
- 2.5.2 Balance the above equation. (10)
- 2.5.3 What mass of H_2O_2 is required to produce 100 mg of O_2 ? (5)
- [46]**

QUESTION 3

- 3.1 State Le Chatelier's principle. (2)
- 3.2 Consider the equilibrium:
- $$\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g}) \quad (\Delta H = +ve)$$
- How will the position of the equilibrium be affected by the following changes:
- 3.2.1 Adding H_2 to the system. (2)
- 3.2.2 Adding a catalyst to the system. (2)
- 3.2.3 Increasing the temperature to 1000 K. (2)
- 3.2.4 Decreasing the volume of the reaction vessel. (2)
- 3.3 Consider the equilibrium:
- $$\text{HCN}(\text{aq}) + \text{OH}^-(\text{aq}) \rightleftharpoons \text{CN}^-(\text{aq}) + \text{H}_2\text{O}(\text{l})$$
- 3.3.1 Is the above equilibrium a heterogeneous or a homogeneous equilibrium? Give a reason for your answer. (2)
- 3.3.2 Write the equilibrium constant expression for this reaction. (2)
- 3.3.3 If the equilibrium constant = 0,915 for the above reaction, comment on the relative quantities of reactants and products in the above reaction and on the equilibrium position. (3)

QUESTION 3 (CONTINUED)

- 3.4 Sulfuryl chloride (SO_2Cl_2) is used in organic chemistry as a chlorinating agent. At moderately high temperatures it decomposes as follows:



with $K_C = 0,045$ at 650 K.

- 3.4.1 A sample of 8,25 g of SO_2Cl_2 is placed in a 1,00 L reaction vessel and heated to 650 K. What are the equilibrium concentrations of all of the species? (11)
- 3.4.2 What fraction of SO_2Cl_2 has decomposed? (2)

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QUESTION 4

- 4.1 For each of the following pairs of atoms:

F and Li; As and Br

Pick the atom or atoms with:

- 4.1.1 The more favourable (exothermic) electron affinity (2)
- 4.1.2 The higher ionization energy (2)
- 4.1.3 Larger size (2)
- 4.2 Arrange the atoms Mg, Ca and S in order of increasing ionization energy. Motivate your answer by giving the general trends in ionization energy and explain why these trends are observed. (9)

- 4.3 Consider the following elements:

Sc, As, S

- 4.3.1 Arrange these elements in order of increasing atomic size. Explain your order. (3)
- 4.3.2 Explain the trend in atomic size which you have suggested above. (6)
- 4.4 Write equations corresponding to the following:
- 4.4.1 The second ionization energy of Mg. (1)
- 4.4.2 The electron affinity of Se. (1)

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QUESTION 5

- 5.1 Distinguish between molecular geometry and electron domain geometry using suitable examples. (4)
- 5.2 Consider the molecule: POCl_3
- 5.2.1 Sketch the Lewis structure for this molecule. (2)
- 5.2.2 Use VSEPR theory to predict the shape of this molecule. (3)
- 5.2.3 What electron domain geometry and bond angle do you associate with this molecule? (2)
- 5.2.4 Is the above molecule polar or non-polar? Explain. (2)
- 5.3 A polyatomic ion is composed of N and an unknown element X. The skeletal Lewis structure for this ion is $[\text{X}-\text{N}-\text{X}]^-$. The ion X^{2-} has the same electron configuration as Ne with 8 protons.
- 5.3.1 Identify the element X. (2)
- 5.3.2 Sketch the Lewis structure for this ion and use VSEPR theory to predict the shape of this ion. (6)

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QUESTION 6

- 6.1 Identify the most significant intermolecular forces present in each of the following substances:
- 6.1.1 FeCl_3 in water (2)
- 6.1.2 CO (2)
- 6.1.3 HCl (2)
- 6.1.4 Ar (2)
- 6.2 Consider the following compounds:
- 1-pentanol ($\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$)**
Hexane ($\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$)
- 6.2.1 List all the different types of intermolecular forces that exist in each compound. (3)
- 6.2.2 One of the compounds has a normal boiling point of 69°C , and the other has a normal boiling point of 138°C . Which is the boiling point of hexane? Explain your answer. (4)
- 6.2.3 One of the compounds has a viscosity of $0,313 \text{ g}/(\text{cm}\cdot\text{s})$ and the other a viscosity of $2,987 \text{ g}/(\text{cm}\cdot\text{s})$. Assign these viscosities to the above compounds. Explain your answer. (4)

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