FACULTY OF SCIENCE

DEPARTMENT OF APPLIED CHEMISTRY
NATIONAL DIPLOMA: FOOD AND BIOTECHNOLOGY

MODULE   CET1A2E
CHEMISTRY 1 THEORY

CAMPUS   DFC

NOVEMBER EXAMINATION

DATE: /2014   SESSION: 12:30 – 15:30

ASSESSOR   DR W MAXAKATO
PROF A MISHRA

INTERNAL MODERATOR   MS L E MACKECHNIE

DURATION   3 HOURS   MARKS 150

NUMBER OF PAGES: 8 PAGES AND 1 ANNEXURE

INSTRUCTIONS: PART A AND PART B MUST BE ANSWERED IN SEPARATE EXAMINATION BOOKS, MAKE SURE YOU MARK EACH BOOK CLEARLY.
GIVE ALL NUMERICAL ANSWERS TO THE CORRECT NUMBER OF SIGNIFICANT FIGURES AND WITH APPROPRIATE UNITS
CALCULATORS ARE PERMITTED (ONLY ONE PER STUDENT)

REQUIREMENTS:
2 x EXAMINATION BOOKS

PHYSICAL CONSTANTS:

Avogadro's number: $N_A = 6,022 \times 10^{23}$ objects mol^{-1}

Volume: 1 litre, $L = 1000 \text{ mL} \equiv 1 \text{ dm}^3 = 1000 \text{ cm}^3$

Molarity: $1\ M \equiv 1 \text{ mol.L}^{-1} \equiv 1 \text{ mol.dm}^{-3}$

pH : $pH = -\log [H_3O^+]$

K_W : $1 \times 10^{-14} = [H_3O^+][OH^-]$

A Periodic Table and a list of anions and cations are attached to this question paper.

PART A – INORGANIC CHEMISTRY

INSTRUCTIONS FOR PART A

Answer all questions in PART A in a separate answer book.

Clearly label this answer book: INORGANIC

SECTION 1 – MULTIPLE CHOICE

Answer section A in your answer book and clearly indicate the question number and the letter choice. For Example: 27 = E.

1. If aluminium reacts with non-metal X to form a compound with the general formula: Al_2X_3, what is the most likely formula for the compound that is formed between potassium and non-metal X?
   A. K_2X_3
   B. K_3X_2
   C. K_2X
   D. KX_3

2. The correct name for $H_2S(aq)$ is:
   A.   Hydrogen sulphide
   B.   Sulphuric acid
   C.   Sulphurous acid
   D.   Hydrosulphuric acid

3. Potassium carbonate (K_2CO_3) reacts with hydrochloric acid (HCl) as follows:

   $K_2CO_3(aq) + HCl(aq) \rightarrow KCl(aq) + H_2O(l) + CO_2(g)$ **(unbalanced)**

   What volume of 0.100 M HCl is required to completely neutralise 20.0 mL of 0.125 M K_2CO_3?
   A.   20.0 mL
   B.   25.0 mL
   C.   50.0 mL
   D.   12.5 mL

4.   According to the Arrhenius theory an acid is a substance that:
A.   increases the concentration of hydrogen ions when dissolved in water
B.   can donate protons to another substance
C.   increases the concentration of hydroxide ions when dissolved in water
D.   can donate hydroxide ions to another substance

5.   The oxidation state of manganese (Mn) in the permanganate ion (MnO_4^-) is:
A. -4
B. $+3$
C. $+7$
D. -6

6.   The correct answer (reported to the proper number of significant figures) for $6.3 \times 3.25 =$
A.   20
B.   20.5
C.   20.48
D.   20.475

[6 x 2.5 = <u>15</u>]

SECTION 2

QUESTION 1

1.1   Complete and write balanced chemical equations *(including physical states)* for each of the following chemical reactions. In each case identify the type of a reaction:

1.1.1   The heating of solid potassium chlorate.   (5)
1.1.2   Liquid benzene burns in air.   (5)

1.2   Balance the following redox reaction by showing half-reactions and the overall reaction.

$$Sn^{2+} + Fe^{3+} \rightarrow Sn^{4+} + Fe^{2+}$$ (4)

1.3   The following results were obtained from replicate determination of the lead content in a blood sample: 0.752, 0.756, 0.752, 0.751 and 0.760 ppm Pb. Calculate the following parameters using the statistical mode on your calculator:

1.3.1   Mean   (2)
1.3.2   Standard deviation   (2)
1.3.3   Median   (2)

QUESTION 1 continued

1.4   Acrylonitrile (C_3H_3N) is the building block for polyacrylonitrile fibres and a variety of plastics. It is produced from gaseous propylene, ammonia and oxygen according to the following balanced equation.

$$2C_3H_6(g) + 2NH_3(g) + 3O_2(g) \rightarrow 2C_3H_3N(g) + 6H_2O(g)$$

1.4.1   What mass of acrylonitrile can be produced from a mixture of 1.00 kg of propylene (C_3H_6), 1,50 kg of ammonia and 2,00 kg of oxygen.   (12)

1.4.2   What masses of excess reactants remain at the end of the reaction?   (6)

1.5   Does good precision always guarantee highly accurate results? Give a reason to support your answer.   (3)
                                                                                    [19]

QUESTION 2

2.1   Commercial concentrated sulphuric acid is 98% H_2SO_4 by mass and has a density of 1.84 g.moL^{-1}. Calculate the **molar concentration** of the sulphuric acid in a solution made by adding 25.0 mL of the concentrated sulphuric acid in enough water to make a 500 mL solution.   (6)

2.2   A 346.3 mg of iron ore that contained only Fe and O was dissolved in an acid and the Fe was converted to Fe^{2+}. The sample was then titrated with 25.59 mL of a 0.02922 M MnO^{4-} solution. The balanced chemical equation for this reaction is:

$$MnO^{4-}(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$$

Calculate the mass per mass percent (% m/m) of iron ore.   (7)

2.3   A 25.00 mL sample of a vinegar (CH_3COOH) was diluted to 250.0 mL volumetric flask and labelled solution 1. A 25.00 mL portion of this solution was diluted to 100.0 mL volumetric flask and labelled solution 2. A 25.00 mL portion of solution 2 required 24.91 mL of a 0.09971 M NaOH solution to reach the end point.

$$CH_3COOH(aq) + NaOH(aq) \rightarrow CH_3COONa(aq) + H_2O(l)$$

Calculate the mass per volume percent (% m/v) of CH_3COOH in the original sample. [Molar mass (gmol^{-1}): CH_3COOH = 60.053]   (8)
                                                                                    [21]

PART B (ORGANIC) is on the next page

PART B (ORGANIC)

INSTRUCTIONS FOR PART B

Answer all questions in PART B in a separate answer book.

Clearly label this answer book: ORGANIC

SECTION 1 – MULTIPLE CHOICE

Answer section A in your answer book and clearly indicate the question number and the letter choice. For Example: 27 = E.

1.   Which among the following is functional group name is CORRECTLY matched with its structure?
A.   Alkane, CH_3CH_2OH
B.   Alkene, $CH_3CH_2CH_3$
C.   Alkyl halide, CH_3CH_2X
D.   Cyclobutane, $CH_3CH_2 H_2CH_3$

2.   During a combustion reaction, a carbon compound reacts with oxygen to produce
A.   Carbon dioxide only
B.   Water only
C.   Carbon dioxide and water
D.   Carbon monoxide and water

3.   The number of sp^2 hybridized carbon in benzene molecule are
A.   3
B.   6
C.   2
D.   None

4.   A nucleophile is a chemical species which is/has
A.   a negative charge
B.   a positive charge
C.   neutral
D.   free radical

5.   Sulfonation of benzene is an example of
A. addition reaction
B. elimination reaction
C. electrophilic substitution
D. nucleophilic substitution

6.   The *cis / trans* isomerism is best classified as
A.   geometrical isomerism
B.   stereoisomerism
C.   constitutional isomerism
D.   None of above

7.   What is the general formula for a secondary alkyl halide?

A. $R–CH_2Cl$

B. $R_2–CHCl$

C. $R–CHCl_2$

D. $R_3–CCl_2$

8.   The name Grignard reagent is used for

A.   alkyl halide

B.   alkyl lithium

C.   alkyl magnesium halide

D.   alkyl manganese halide

9.   When an alkene reacts with halogen in the presence of carbon tetrachloride, the product obtained has

A.   only one halogen group

B.   two halogen groups

C.   three halogen groups

D.   no halogen groups

[9 x 2 = 18]

SECTION 2

QUESTION 1

MATCH THE TERMS GIVEN IN THE FOLLOWING TABLE WITH THE STATEMENTS BELOW BY WRITING ONLY THE NUMBER OF THE STATEMENT AND THE CHOSEN TERM.

Acylation	Electrophilic substitution	Hydrogenation
Combustion	Esterification	Hydrohalogenation
Dehydration	Halogenation	Nucleophilic substitution
Dehydrohalogenation	Hydration	Reduction

1.1   Hexene reacts with hydrogen to give hexane.   (2)

1.2   Butane reacts with oxygen to give carbon dioxide and water.   (2)

1.3   Pentene is made from the reaction of 2-iodo pentane with potassium hydroxide.   (2)

1.4   Methyl chloride reacts with water to produce methanol.   (2)

1.5   Chlorobenzene is made from the reaction of benzene with chlorine in the presence of a catalyst.   (2)

[10]

QUESTION 2

Given below is the chemical structure of vanillin which is flavoring agent in vanilla extract.
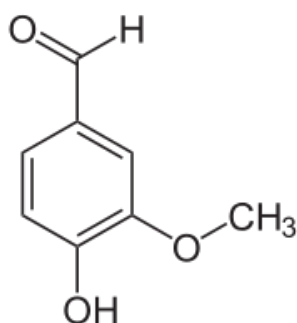
2.1	Identify different functional groups present in this structure.	(4)
2.2	Give the molecular formula of vanillin.	(3)
2.3	State how many sp3, sp2 and sp hybridized carbon atoms there are in Vanillin.	(3)
		[10]

QUESTION 3

3.1   Given below are the hydro halogenation reactions on an alkene substrate. Provide the major and minor products in each case.

3.1.1   (5)

3.1.2   (5)

3.2	What rule is followed in these reactions?	(2)
3.3	State the rule.	(3)
3.4	What catalyst is used to reverse the type of products obtained?	(2)
		[17]

UNIVERSITY OF JOHANNESBURG
Department of Chemical Technology

Atomic Number

2	
He	
	4.0026

Atomic Weight

1																		2
H 1.0079																		**He** 4.0026
3 **Li** 6.941	4 **Be** 9.0122											5 **B** 10.811	6 **C** 12.011	7 **N** 14.007	8 **O** 15.999	9 **F** 18.998	10 **Ne** 20.179
11 **Na** 22.990	12 **Mg** 24.305											13 **Al** 26.982	14 **Si** 28.086	15 **P** 30.974	16 **S** 32.064	17 **Cl** 35.453	18 **Ar** 39.948
19 **K** 39.098	20 **Ca** 40.078	21 **Sc** 44.956	22 **Ti** 47.88	23 **V** 50.942	24 **Cr** 51.996	25 **Mn** 54.938	26 **Fe** 55.847	27 **Co** 58.933	28 **Ni** 58.69	29 **Cu** 63.546	30 **Zn** 65.39	31 **Ga** 69.723	32 **Ge** 72.61	33 **As** 74.922	34 **Se** 78.96	35 **Br** 79.904	36 **Kr** 83.80
37 **Rb** 85.47	38 **Sr** 87.62	39 **Y** 88.906	40 **Zr** 91.224	41 **Nb** 92.906	42 **Mo** 95.94	43 **Tc** (98)	44 **Ru** 101.07	45 **Rh** 102.91	46 **Pd** 106.42	47 **Ag** 107.87	48 **Cd** 112.41	49 **In** 114.82	50 **Sn** 118.71	51 **Sb** 121.75	52 **Te** 127.60	53 **I** 126.90	54 **Xe** 131.29
55 **Cs** 132.91	56 **Ba** 137.33	57 **La** 138.91	72 **Hf** 178.49	73 **Ta** 180.95	74 **W** 183.85	75 **Re** 186.2	76 **Os** 190.2	77 **Ir** 192.22	78 **Pt** 195.08	79 **Au** 196.97	80 **Hg** 200.59	81 **Tl** 204.38	82 **Pb** 207.2	83 **Bi** 208.98	84 **Po** (209)	85 **At** (210)	86 **Rn** (222)
87 **Fr** (223)	88 **Ra** 226.03	89 **Ac** 227.03															

58 **Ce** 140.12	59 **Pr** 140.91	60 **Nd** 144.24	61 **Pm** 146.92	62 **Sm** 150.36	63 **Eu** 151.97	64 **Gd** 157.25	65 **Tb** 158.93	66 **Dy** 162.50	67 **Ho** 164.93	68 **Er** 167.26	69 **Tm** 168.93	70 **Yb** 173.04	71 **Lu** 174.97
90 **Th** 232.04	91 **Pa** 231.04	92 **U** 238.03	93 **Np** 237.05	94 **Pu** (244)	95 **Am** (234)	96 **Cm** (247)	97 **Bk** 247	98 **Cf** (251)	99 **Es** (252)	100 **Fm** (257)	101 **Md** (258)	102 **No** (259)	103 **Lr** (260)