UNIVERSITY
OF
JOHANNESBURG

FACULTY OF SCIENCE

DEPARTMENT OF APPLIED CHEMISTRY
NATIONAL DIPLOMA BIOTECHNOLOGY
NATIONAL DIPLOMA FOOD TECHNOLOGY

MODULE: ANALYTICAL CHEMISTRY 2BBF: THEORY CET1BT2/CET2TB1

CAMPUS: DFC

NOVEMBER EXAMINATION

DATE: 25/11/2019 **SESSION: 08:00 – 11:00**

ASSESSOR **DR M DIMPE**
DR M MAMO

INTERNAL MODERATOR **PROF. P.N NOMNGONGO**

DURATION 2.5 HOURS **MARKS: 125**

NUMBER OF PAGES: 9 PAGES, INCLUDING A DATA SECTION AND A PERIODIC TABLE.

INSTRUCTIONS: CALCULATORS ARE PERMITTED (ONLY ONE PER STUDENT).
HAND-IN QUESTION PAPER WITH THE ANSWER SHEET.

REQUIREMENTS: MULTIPLE CHOICE ANSWER SHEET.

ANSWER BOOK.

SECTION A: MULTIPLE CHOICE

Answer this section on the pink UJ MULTIPLE CHOICE ANSWER SHEET.

1. The % T of a solution with an absorbance of 0.235 is:

A. 67.4
B. 32.9
C. 45.5
D. 58.2

2. The analytically useful half-reaction of dichromate as a strong oxidant is:

A. $Cr_2O_7^{2-} + 14H^+ + 9e^- \rightarrow 2Cr^{3+} + 7H_2O$
B. $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$
C. $Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2CrO_4^{2-} + 7H_2O$
D. $Cr_2O_7^{2-} + 7H_2O + 6e^- \rightarrow 2Cr^{3+} + 14OH^-$

3. A primary standard substance must possess all of the following characteristics, except one:

A. It must not be stable in air.
B. It must be soluble in the titration medium.
C. It must have a large molar mass to minimize weighing errors.
D. It must have a high purity.

4. Expressing 18.25% (m/m) Fe_3O_4 as % (m/m) Fe_2O_3, results in a % (m/m) Fe_2O_3 equal to:
[Molar masses (g mol^{-1}): Fe_3O_4 = 231.541; Fe_2O_3 = 159.694]

A. 12.45%
B. 15.29%
C. 18.88%
D. 25.77%

5. The pH of the solution formed when 20.00 mL of a 0.234 M NaOH solution is mixed with 480.00 mL of distilled water is:

A. 13.37
B. 12.23
C. 11.21
D. 11.97

6. An HNO_2 / NO^{2-} buffer of pH = 3.25, given that K_a (HNO_2) = 7.1×10^{-4}, has an NO^{2-} : HNO_2 ratio of:

A. 1.513
B. 1.263
C. 1.632
D. 1.824

7. Liquid chromatography is generally used for separating and determining:

A. thermally unstable and non-volatile compounds
B. thermally stable and volatile compounds
C. thermally unstable and volatile compounds
D. thermally stable and non-volatile compounds

8. The molar concentration of concentrated 48.0% (m/m) HBr which has an SG = 1.51 is:
[Molar mass (g mol^{-1}): HBr = 80.9]

A. 10.1 M
B. 9.0 M
C. 8.6 M
D. 11.4 M

9. How many grams of NaOH are there in 500.00 mL of a 0.175 N NaOH solution?
[Molar mass (g mol^{-1}): NaOH = 40.00]

A. 2.19×10^{-3} g
B. 114 g
C. 3.50 g
D. 14.0 g

10. The following are general steps that are involved in a determination by precipitation, except for
A. Formation of a precipitate
B. Filtration of precipitate
C. Washing of precipitate
D. Digestion of precipitate

11. Which one of the following is the weakest acid?

A. HF ($K_a = 6.8 \times 10^{-4}$)
B. HClO ($K_a = 3.0 \times 10^{-8}$)
C. HCN ($K_a = 4.9 \times 10^{-10}$)
D. Acetic acid ($K_a = 1.8 \times 10^{-5}$)

12. What is the pH of a 0.0035 M $Ba(OH)_2$ solution?

A. 9.04
B. 11.54
C. 2.46
D. 11.85

13. The concentration of H_3O^+ in a solution is 7 x 10^{-4} M at 25°C. What is its hydroxide-ion concentration?

A. 7 x 10^{-4} M
B. 1 x 10^{-10} M
C. 3 x 10^{-10} M
D. 1 x 10^{-11} M

14. Which of the following statements is true concerning an aqueous solution of the weak base NH_3?

A. OH^- is a stronger base than NH_3
B. OH^- is a stronger acid than NH_4^+
C. NH_4^+ is a stronger acid than H_3O^+
D. NH_3 is a weaker base than H_2O

15. Rank H_3PO_4, $H_2PO_4^-$, and HPO_4^{2-} in order of increasing acid strength.

A. $HPO_4^{2-} < H_2PO_4^- < H_3PO_4$
B. $H_2PO_4^- < HPO_4^{2-} < H_3PO_4$
C. $H_2PO_4^- < H_3PO_4 < HPO_4^{2-}$
D. $HPO_4^{2-} < H_3PO_4 < H_2PO_4^-$

16. The autoionization of water, as represented by the equation below, is known to be endothermic. Which of the following correctly states what occurs as the temperature of water is raised?

$$H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

A. The pH of the water decreases, and the water becomes more acidic.
B. The pH of the water decreases, and the water remains neutral.
C. The pH of the water increases, and the water remains neutral.
D. The pH of the water does not change, and the water remains neutral.

17. HA is a weak acid. Which equilibrium corresponds to the equilibrium constant K_b for A^-?

A. $HA (aq) + H_2O (l) \rightleftharpoons H_2A^+ (aq) + OH^-(aq)$

B. $A^- (aq) + H_3O^+ (aq) \rightleftharpoons HA (aq) + H_2O (l)$

C. $HA (aq) + OH^- (aq) \rightleftharpoons H_2O (l) + H^+ (aq)$

D. $A^- (aq) + H_2O (l) \rightleftharpoons HA (aq) + OH^- (aq)$

18. What is the hydroxide-ion concentration in a solution formed by combining 200 mL of 0.15 M HCl with 300. mL of 0.090 M NaOH at 25°C?

NaOH(aq) + HCl(aq) $\rightarrow$ NaCl(aq) + H2O(l)

A. 1.7 x 10^{-13} M

B. 0.090 M

C. 1.7 x 10^{-12} M

D. 0.054 M

19. In a solution, when the concentrations of a weak acid and its conjugate base are equal, …………..

A. the system is not at equilibrium

B. the buffering capacity is significantly decreased

C. the -log of the $[H^+]$ and the -log of the K_a are equal

D. All of the above are true.

20. Indeterminate errors are caused by ……………whereas method errors are caused by…………

A. Chemical or physical behaviour of the reagents and reactions; random events

B. The analyst’s personal judgment and care; chemical or physical behaviour of the reagents and reactions

C. Random events; the analyst’s personal judgment and care

D. Random events; chemical or physical behaviour of the reagents and the reaction

20 × 2.5 = [50]

SECTION B: LONG QUESTIONS

Answer the following questions in your answer book.

QUESTION 1

Describe the preparation of the following solutions:

1.1 500 mL of 5% (m/v) Cl^- from NaCl. (5)

1.2 5.00 L of a 500 ppm Na_2SO_4 solution from a 0.25% (m/v) Na_2SO_4 solution (6)

1.3 20 L of 6M HCl from the concentrated reagent which is 32% (m/m) and has an SG (specific gravity) of 1.21. (7)

1.4 5.00 L of 50 ppm Na^+ from 2.00 L of 200 ppm Na^+ (2)

[20]

QUESTION 2

2.1 What is the difference between gas solid chromatography and gas-liquid chromatography. (4)

2.2 List four major components of GC. (4)

(a) Electromagnetic radiation (2)

(b) Transmittance (2)

(c) Qualitative analysis (2)

(d) Monochromator (2)

(e) Atomisation (2)

2.3 What do the symbols “A” and “a” in the Beer-Lambert law mean? (2)

[20]

SECTION C: LONG QUESTIONS

QUESTION 3

3.1 Calculate the present of ionization of acetic acid (K_a = 1.8 x 10^{-5}) of the 1.0 M $HC_2H_3O_2$ solution. (3)

3.2 Lactic acid ($HC_3H_5O_5$) is a waste product that accumulates in muscle tissue during exertion, leading to pain and a feeling of fatigue. In a 0.100 M aqueous solution, lactic acid is 3.7% dissociated. Calculate the value of K_a for this acid. (3)

3.3 Calculate the pH of a solution containing 0.75 M lactic acid (k_a = 1.4 x 10^{-4}) and 0.25 M sodium lactate. Lactic acid ($HC_3H_5O_3$) is a common constituent of biological system e.g. in milk and in human muscle tissue during exertion. (5)

[11]

QUESTION 4

4.1 Hydrogen cyanide gas (HCN), a powerful respiratory inhibitor, is highly toxic. It is very weak acid (Ka = 6.2 x 10^{-10}) when dissolved in water. If a 50.0 mL sample of 0.100 M HCN is titrated with 0.100 M NaOH, calculate the pH of the solution:

(a) After 8.00 mL of 0.100 M NaOH had been added (7)

(b) At the halfway (mid) point of the titration (2)

(c) At the equivalent point of the titration (7)

4.2 The amount of ascorbic acid, $C_6H_8O_6$, in orange juice was determined by oxidizing the ascorbic acid to dehydroascorbic acid, $C_6H_6O_6$, with a known excess of $I_3^–$, and back titrating the excess $I_3^–$ with $Na_2S_2O_3$. A 5.00-mL sample of filtered orange juice was treated with 50.00 mL of excess 0.01023 M $I_3^–$. After the oxidation was complete, 13.82 mL of 0.07203 M $Na_2S_2O_3$ was needed to reach the starch indicator end point. Calculate the concentration of ascorbic acid in milligrams per 100 mL. (8)

Consider the following unbalanced chemical reactions:

(a) $C_6H_8O_{6\,(aq)} + I_3^- \rightarrow C_6H_6O_{6(aq)} + I^-_{(aq)} + 2H^+_{(aq)}$

(b) $S_2O_3^{2-}{}_{(aq)} + I_3^-{}_{(aq)} \rightarrow S_4O_6^{2-}{}_{(aq)} + I^-_{(aq)}$

[24]

FULL MARKS: 125
TOTAL MARKS: 125

DATA

$\mathbf{K_w = 1 \times 10^{-14}}$

$\mathbf{pH = pK_a + \log (C_b / C_a) = pK_a + \log (n_b / n_a)}$

$\mathbf{c = f \times \lambda}$

$\mathbf{E = h \times f}$

$\mathbf{T = P_{out} / P_{in}}$

$\mathbf{\%\ T = P_{out} / P_{in} \times 100}$

$\mathbf{A = a \times b \times C}$

$\mathbf{A = -\log_{10} T}$

UNIVERSITY OF JOHANNESBURG

Department of Applied Chemistry

Atomic Number — 2 **He** *4.0026* — Atomic Weight

1 **H** *1.0079*																	2 **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)*

2/...