UNIVERSITY OF JOHANNESBURG

FACULTY OF SCIENCE

DEPARTMENT OF APPLIED CHEMISTRY
NATIONAL DIPLOMA BIOTECHNOLOGY
NATIONAL DIPLOMA FOOD TECHNOLOGY

MODULE ANALYTICAL CHEMISTRY 2BBF: THEORY CET1BT2

CAMPUS DFC

NOVEMBER EXAMINATION

DATE: 09 /11/2015 **SESSION: 8:30 – 11:30**

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INTERNAL MODERATOR **MS H DU PLESSIS-FISCHER**

DURATION 3 HOURS **MARKS: 150**

NUMBER OF PAGES: 8 PAGES, INCLUDING A DATA SECTION.

INSTRUCTIONS: CALCULATORS ARE PERMITTED (ONLY ONE PER STUDENT).

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. The molarity of a 0.1700 N solution of IO_3^- used in a reaction where 10 electrons are transferred is:

A. Not calculable without seeing the balanced half-reaction equation
B. 0.1700 M
C. 1.700 M
D. 0.01700 M

8. If the absorbance of a standard 0.1321 M solution of $KMnO_4$ is 0.2450 under certain operating conditions, then the concentration of an unknown $KMnO_4$ solution with an absorbance of 0.1980 under identical operating conditions is:

A. 0.1456 M
B. 0.09853 M
C. 0.1068 M
D. 0.1795 M

9. The following are all abbreviations of spectroscopic techniques, except for:

A. GLC
B. FES
C. AAS
D. UV-Vis

10. The pH of a 0.25 M NH_4Cl solution is:
[K_b (NH_3) = 1.8 × 10^{-5}]

A. 4.929
B. 6.750
C. 3.284
D. 11.327

11. The OH^- molar concentration of a solution with a pH of 3.45 is:

A. 7.85 × 10^{-2} M
B. 2.56 × 10^{-4} M
C. 3.55 × 10^{-4} M
D. 2.82 × 10^{-11} M

12. Based on the following reaction equation and data, the limiting reagent(s) is/are:

	4A	**+**	**2B**	**+**	**3C**	$\rightarrow$	**D**
Concentration (M)	0.4444		0.2222		0.1111		
Volume (mL)	10.00		20.00		40.00		

A. reactant A
B. reactant B
C. reactant C
D. reactant A, B and C

13. The number of moles of I^- formed from a 1.857 g sample that assays 59.23% (m/m) MgI_2 is:
[Molar mass (g mol^{-1}): MgI_2 = 278.12]

A. 1.100 mol
B. 2.200 mol
C. 3.955×10^{-5} mol
D. 7.910×10^{-3} mol

14. In order to prepare 250.00 mL of a 0.20 N H_2SO_4 solution for use in acid-base titrimetry, you have to dilute the following volume of 2.0 M H_2SO_4:

A. 25.00 mL
B. 50.00 mL
C. 12.50 mL
D. 10.00 mL

15. In order to prepare 750.00 mL of 1.00% (m/v) Na^+ solution from a 5.00% (m/v) NaCl solution, you have to dilute the following volume of the 5.00% (m/v) NaCl to 750.00 mL:
[Molar masses (g mol^{-1}): Na = 22.99; NaCl = 58.443]

A. 262 mL
B. 381 mL
C. 150 mL
D. 322 mL

16. .... is a separation technique in which an instrument called a .... produces a readout (graph) called a …………………..:

A. Chromatography; chromatogram; chromatograph
B. Chromatograph; chromatogram; chromatography
C. Chromatography; chromatograph; chromatogram
D. Chromatogram; chromatography; chromatograph

17. 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

18. If a 1.653 g sample liberates 0.2540 g of CO_2 upon reaction with an excess of HCl, then the % (m/m) Na_2CO_3 content of the sample is:
[Molar masses (g mol^{-1}): Na_2CO_3 = 105.99; CO_2 = 44.011]

A. 31.80%
B. 37.00%
C. 72.90%
D. 33.70%

19. The theoretical pH transition range of an acid-base indicator of $K_a = 4.50 \times 10^{-6}$ is:

A. 8.65 – 9.65
B. 7.65 – 9.65
C. 7.65 – 8.65
D. 4.35 – 6.35

20. 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

21. Which of the following reagent combinations would you need if you wanted to prepare a buffer of pH 7.4?
[For H_3PO_4: $K_{a1} = 7.11 \times 10^{-3}$; $K_{a2} = 6.32 \times 10^{-8}$; $K_{a3} = 4.5 \times 10^{-13}$]

A. Na_2HPO_4 and KH_2PO_4
B. Na_3PO_4 and H_3PO_4
C. KH_2PO_4 and H_3PO_4
D. Na_2HPO_4 and Na_3PO_4

22. The pH of a 0.00183 M sodium hydroxide (NaOH) solution is:

A. 10.55
B. 10.98
C. 11.26
D. 11.89

23. If 20.00 mL of an unknown HCl solution (**Solution X**) is diluted to 500.00 mL, and it is found by experiment that the HCl concentration in this 500.00 mL solution is 3.00×10^{-3} M, then the molar HCl concentration of **Solution X** is:

A. 0.100 M
B. 0.0750 M
C. 3.00×10^{-3} M
D. 1.2×10^{-4} M

24. Select the weak acid from the list below:

A. HI
B. HNO_3
C. $HClO_4$
D. HNO_2

25. The reaction equation that best describes the reaction of magnesium ions with the disodium salt of EDTA is:

A. $Mg^{2+} + H_2Y^{2-} \rightarrow MgY^{2-} + 2H^+$
B. $Mg^{2+} + H_2Y^{2-} \rightarrow MgH_2Y$
C. $2Mg^{2+} + H_2Y^{2-} \rightarrow Mg_2Y + 2H^+$
D. $Mg^{2+} + Na_2Y^{2-} \rightarrow MgY^{2-} + 2Na^+$

26. 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

26 × 2.5 = [65]

SECTION B: LONG QUESTIONS

Answer the following questions in your answer book.

Instructions: Report the pH to two decimal places

QUESTION 1

1.1 Describe the preparation of 1000 mL of a 0.1000 M OH^- solution from a 5% (m/v) $Ba(OH)_2$ solution.
[Molar masses (g mol^{-1}): OH^- = 17.01; $Ba(OH)_2$ = 171.35] (7)

1.2 Calculate the molar concentration of:

1.2.1 100.00 mL of 5% (m/v) NaCl
[Molar mass (g mol^{-1}): NaCl = 58.44] (3)

1.2.2 250.00 mL of 650 ppm HCl
[Molar mass (g mol^{-1}): HCl = 36.46] (3)

1.2.3 2 L of 450 ppt HNO_3
[Molar mass (g mol^{-1}): HNO_3 = 63.01] (2)

[15]

QUESTION 2

2.1 Calculate the pH of a mixture of 75.00 mL of 0.1265 M H_2SO_4 and 160.00 mL of 0.1265 M KOH. (10)

2.2 Calculate the relevant reagent volumes and/or masses required to prepare the following buffers:

2.2.1 A buffer of pH = 9.15 from 0.2843 M NH_3 and 1500.00 mL of 0.2592 M HCl.
[K_b (NH_3) = 1.75×10^{-5}] (11)

2.2.2 1000.00 mL of a buffer of pH = 4.90 from 0.1783 M CH_3COOH and 0.2691 M CH_3COONa.
[K_a (CH_3COOH) = 1.75×10^{-5}] (6)

2.3 Calculate the pH in the titration of 15.00 mL of 0.2000 M $Ba(OH)_2$ with 0.1500 M HCl at the following stages in the titration:

2.3.1 Initial pH. (4)

2.3.2 After addition of 5.00 mL of HCl solution. (11)

[42]

QUESTION 3

3.1 The calcium present in 0.5839 g of a sample was determined by precipitating the Ca^{2+} as CaC_2O_4. After filtering, washing and re-dissolving the precipitate in acid, the liberated oxalate ($C_2O_4^{2-}$) was titrated against 21.69 mL of a 0.05573 M $KMnO_4$ solution, during which CO_2 and Mn^{2+} were reaction products in acid medium. Calculate the weight percentage of Ca in the sample, after writing and balancing all half-reaction and overall reaction equations occurring in acid medium.
[Molar mass (g mol^{-1}): Ca = 40.08] (11)

3.2 An EDTA solution was standardised by titration against a zinc solution which was prepared by dissolving 0.6593 g of pure zinc metal in 5 mL of HCl and diluting to 500.00 mL. A volume of 10.95 mL of the EDTA solution was required to titrate 10.15 mL of this zinc solution. Then 12.55 mL of this EDTA solution was used to titrate the calcium in a 1.562 g sample of powdered milk. Calculate the % (m/m) Ca^{2+} in powdered milk.
[Molar masses (g mol^{-1}): Ca = 40.08; Zn = 65.37] (9)
[20]

QUESTION 4

4.1 Describe the general use of gas chromatography (GC). (4)

4.2 Describe the function of the following GC components:

4.2.1 Detector (1)
4.2.2 Oven (2)
4.2.3 Column (3)
[10]

DATA

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

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

$$c = f \times \lambda \qquad E = h \times f$$

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

$$A = a \times b \times C \qquad A = -\log_{10} T$$