UNIVERSITY
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: $10 / 11 / 2014$
ASSESSOR
INTERNAL MODERATOR
DURATION 3 HOURS
SESSION: 8:30-11:30
DR S MAOELA
MS H DU PLESSIS-FISCHER
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.
GRAPH PAPER

## SECTION A: MULTIPLE CHOICE

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

1. The approximate diameter of the particles in an HPLC column is:
A. $\quad 150 \mu \mathrm{~m}$
B. $\quad 50 \mu \mathrm{~m}$
C. $\quad 500 \mu \mathrm{~m}$
D. $5 \mu \mathrm{~m}$
2. Expressing $18.25 \%(m / m) \mathrm{Fe}_{3} \mathrm{O}_{4}$ as $\%(\mathrm{~m} / \mathrm{m}) \mathrm{Fe}_{2} \mathrm{O}_{3}$, results in a $\%(\mathrm{~m} / \mathrm{m}) \mathrm{Fe}_{2} \mathrm{O}_{3}$ equal to:
[Molar masses $\left(\mathrm{g} \mathrm{mol}^{-1}\right)$ : $\mathrm{Fe}_{3} \mathrm{O}_{4}=231.54 ; \mathrm{Fe}_{2} \mathrm{O}_{3}=159.69$ ]
A. $12.45 \%$
B. $15.29 \%$
C. $18.88 \%$
D. $25.77 \%$
3. The molarity of a 0.1700 N solution of $\mathrm{IO}_{3}^{-}$used in a reaction where 10 electrons are transferred, is:
A. $\quad 0.01700 \mathrm{M}$
B. $\quad 1.700 \mathrm{M}$
C. $\quad 0.1700 \mathrm{M}$
D. not calculable without seeing the balanced half-reaction equation
4. Select the weak acid from the list below:
A. $\mathrm{HClO}_{4}$
B. $\mathrm{HNO}_{2}$
C. $\mathrm{HNO}_{3}$
D. HI
5. After adding 10 mL of a 0.10 M NaOH solution to 20 mL of a $0.10 \mathrm{M} \mathrm{CH}_{3} \mathrm{COOH}$ (acetic acid) solution, the resulting solution is a:
A. buffer
B. weak acid
C. weak base
D. mixture of a strong base and weak base
6. The pH of the buffer obtained by mixing 82.03 g of $\mathrm{CH}_{3} \mathrm{COONa}$ with 2.000 L of $0.500 \mathrm{M} \mathrm{CH}_{3} \mathrm{COOH}$, is equal to the:
[Molar mass $\left(\mathrm{g} \mathrm{mol}^{-1}\right): \mathrm{CH}_{3} \mathrm{COONa}=82.03 ; \mathrm{K}_{\mathrm{a}}\left(\mathrm{CH}_{3} \mathrm{COOH}\right)=1.75 \times 10^{-5}$ ]
A. $\mathrm{K}_{\mathrm{a}}$ of $\mathrm{CH}_{3} \mathrm{COOH}$
B. $\mathrm{K}_{\mathrm{b}}$ of $\mathrm{CH}_{3} \mathrm{COONa}$
C. $\mathrm{pK}_{\mathrm{a}}$ of $\mathrm{CH}_{3} \mathrm{COOH}$
D. $\mathrm{pK}_{\mathrm{b}}$ of $\mathrm{CH}_{3} \mathrm{COONa}$
7. If the absorbance of a standard 0.1321 M solution of $\mathrm{KMnO}_{4}$ is 0.2450 under certain operating conditions, then the concentration of an unknown $\mathrm{KMnO}_{4}$ solution with an absorbance of 0.1980 under identical operating conditions is:
A. $\quad 0.09853 \mathrm{M}$
B. $\quad 0.1068 \mathrm{M}$
C. $\quad 0.1456 \mathrm{M}$
D. $\quad 0.1795 \mathrm{M}$
8. The pH of 20.00 mL of a 0.234 M NaOH solution after mixing with 480.00 mL of distilled water is:
A. $\quad 13.37$
B. $\quad 12.23$
C. $\quad 11.21$
D. 11.97
9. The sequence of wavelengths of the electromagnetic spectrum arranged from longest to shortest is:
A. visible; infrared; ultraviolet; X-ray; radio; gamma
B. infrared; radio; gamma; visible; ultraviolet; X-ray
C. infrared; visible; ultraviolet; X-ray; radio; gamma
D. radio; infrared; visible; ultraviolet; X-ray; gamma
10. The following primary standard may be used for standardising LiOH solutions:
A. HCl
B. Potassium hydrogen phthalate (KHP)
C. $\quad \mathrm{Na}_{2} \mathrm{CO}_{3}$
D. $\mathrm{H}_{2} \mathrm{SO}_{4}$
11. The colour change at the end point of an iodimetric titration is $\qquad$ and at the end point of an iodometric titration is $\qquad$ :
A. colourless to blue; blue to colourless
B. blue to colourless; blue to colourless
C. blue to colourless; colourless to blue
D. colourless to blue; colourless to blue
12. The following are all components of a liquid chromatograph, except for the:
A. column
B. liquid phase reservoirs
C. carrier gas supply system
D. detector
13. The molar $\mathrm{Na}^{+}$concentration in a $3.00 \%(\mathrm{~m} / \mathrm{v}) \mathrm{Na}_{2} \mathrm{SO}_{4}$ solution is:
[Molar masses $\left(\mathrm{g} \mathrm{mol}^{-1}\right): \mathrm{Na}=22.99 ; \mathrm{Na}_{2} \mathrm{SO}_{4}=142.04$ ]
A. $\quad 0.0128 \mathrm{M}$
B. $\quad 0.211 \mathrm{M}$
C. $\quad 0.422 \mathrm{M}$
D. $\quad 0.300 \mathrm{M}$
14. UV-Vis cuvettes should always be:
A. handled by the rough sides
B. dried in a warm oven
C. handled by the clear sides
D. filled so that there are air bubbles in the cuvette
15. The normality of 20.00 mL of a $0.20 \mathrm{M} \mathrm{Ba}(\mathrm{OH})_{2}$ solution is:
A. $\quad 0.0040 \mathrm{~N}$
B. $\quad 0.0020 \mathrm{~N}$
C. $\quad 0.20 \mathrm{~N}$
D. $\quad 0.40 \mathrm{~N}$
16. The $\mathrm{SO}_{4}{ }^{2-}$ in a 0.5001 g sample was precipitated as $\mathrm{BaSO}_{4}$. If 0.1458 g of the $\mathrm{BaSO}_{4}$ precipitate was isolated, the $\%(\mathrm{~m} / \mathrm{m}) \mathrm{SO}_{4}{ }^{2-}$ is:
[Molar masses $\left(\mathrm{g} \mathrm{mol}^{-1}\right): \mathrm{BaSO}_{4}=233.39 ; \mathrm{SO}_{4}{ }^{2-}=96.06$ ]
A. $11.00 \%$
B. $12.00 \%$
C. $13.00 \%$
D. $70.83 \%$
17. The absorbance of a solution with a $\% \mathrm{~T}=25.1$ is:
A. 0.556
B. 0.600
C. $\quad-1.40$
D. 0.500
18. Titrating with a burette that has a leaking tap is an example of $a(n)$ :
A. method error
B. random error
C. personal error
D. instrument error
19. For a good precision, the CV must be less than:
A. $1.2 \%$
B. $0.5 \%$
C. $0.2 \%$
D. $0.02 \%$
20. The theoretical pH transition range for an acid-base indicator with $\mathrm{K}_{\mathrm{a}}=5.50 \times 10^{-5}$ is:
A. $2.26-3.26$
B. $3.26-3.86$
C. $3.26-5.26$
D. $9.26-11.26$
21. The following are all abbreviations of spectroscopic techniques, except for:
A. GLC
B. FES
C. AAS
D. UV-Vis
22. How many grams of NaOH are there in 500.00 mL of a 0.175 N NaOH solution?
[Molar mass ( $\mathrm{g} \mathrm{mol}^{-1}$ ): $\mathrm{NaOH}=40.00$ ]
A. $\quad 114 \mathrm{~g}$
B. $\quad 0.00219 \mathrm{~g}$
C. $\quad 14.0 \mathrm{~g}$
D. $\quad 3.50 \mathrm{~g}$
23. The $\%(\mathrm{~m} / \mathrm{m})$ ascorbic acid content of a 0.2022 g sample of tablets that required 23.75 mL of a $0.04196 \mathrm{M}_{2}$ solution to reach an end point, given that 1 mol ascorbic acid $\equiv 1 \mathrm{~mol}_{2}$, is:
[Molar mass ( $\mathrm{g} \mathrm{mol}^{-1}$ ): Ascorbic acid $=176.13$ ]
A. $88.60 \%$
B. $86.81 \%$
C. $79.23 \%$
D. $65.47 \%$

# 24. The titration of the diprotic acid $\mathrm{H}_{2} \mathrm{SO}_{4}$ with 0.1 M NaOH has end point(s), while the titration of citric acid with 0.1 M NaOH has end point(s): <br> [Citric acid: $\mathrm{K}_{\mathrm{a} 1}=7.45 \times 10^{-4} ; \mathrm{K}_{\mathrm{a} 2}=1.73 \times 10^{-5}$ ] 

A. one; two
B. two; two
C. one; one
D. two; one

## SECTION B: LONG QUESTIONS

## Answer the following questions in your answer book. Instructions: Report the pH to two decimal places

## QUESTION 1

Describe the preparation of the following solutions:
$\left.\begin{array}{ll}1.1 & 750 \mathrm{~mL} \text { of } 1.15 \%(\mathrm{~m} / \mathrm{v}) \mathrm{Na}^{+} \text {solution from solid } \mathrm{Na}_{2} \mathrm{CO}_{3} . \\ \text { [Molar masses }(\mathrm{g} \mathrm{mol} \\ \\ -1\end{array}\right): \mathrm{Na}=22.99 ; \mathrm{Na}_{2} \mathrm{CO}_{3}=105.99$ ]
1.21500 mL of $29.4 \%(\mathrm{~m} / \mathrm{v}) \mathrm{H}_{2} \mathrm{SO}_{4}$ from the concentrated reagent, which is $95.5 \%(\mathrm{~m} / \mathrm{m}) \mathrm{H}_{2} \mathrm{SO}_{4}$ and has a specific gravity $=1.75$.
[Molar mass ( $\mathrm{g} \mathrm{mol}^{-1}$ ): $\mathrm{H}_{2} \mathrm{SO}_{4}=98.08$ ]

## QUESTION 2

2.1 Calculate the pH at the equivalence point of a titration of 20.00 mL of 0.1871 M formic acid $(\mathrm{HCOOH})$ solution with a 0.1121 M NaOH solution.

$$
\begin{equation*}
\left[\mathrm{K}_{\mathrm{a}}(\mathrm{HCOOH})=1.77 \times 10^{-4}\right] \tag{12}
\end{equation*}
$$

2.2 The formaldehyde (HCHO) content of a pesticide was determined by weighing 0.5467 g of the sample into a flask containing 50.00 mL of 0.1005 M KOH and 50.00 mL of $3 \%(\mathrm{~m} / \mathrm{v}) \mathrm{H}_{2} \mathrm{O}_{2}$. Upon heating the following reaction occurred:

$$
\mathrm{OH}^{-}+\mathrm{HCHO}+\mathrm{H}_{2} \mathrm{O}_{2} \rightarrow \mathrm{HCOO}^{-}+2 \mathrm{H}_{2} \mathrm{O}
$$

After cooling, the excess base was titrated with 32.10 mL of $0.04478 \mathrm{M} \mathrm{H}_{2} \mathrm{SO}_{4}$. Write the balanced titration reaction equation and calculate the $\%(\mathrm{~m} / \mathrm{m}) \mathrm{HCHO}$ in the sample.
[Molar mass ( $\mathrm{g} \mathrm{mol}^{-1}$ ): $\mathrm{HCHO}=30.03$ ]
2.3 Calculate the volume of $0.1542 \mathrm{M} \mathrm{HNO}_{2}$ to be added to 1.558 g of $\mathrm{NaNO}_{2}$ in order to prepare a buffer with a $\mathrm{pH}=3.00$.
[Molar mass $\left(\mathrm{g} \mathrm{mol}^{-1}\right): \mathrm{NaNO}_{2}=69.00 ; \mathrm{K}_{\mathrm{a}}\left(\mathrm{HNO}_{2}\right)=7.1 \times 10^{-4}$ ]

## QUESTION 2: (Cont.)

2.4 Calculate the volumes of 0.3500 M HAc and 0.2500 M NaAc required to prepare 750.00 mL of a buffer of $\mathrm{pH}=4.70$.

$$
\begin{equation*}
\left[\mathrm{K}_{\mathrm{a}}(\mathrm{HAc})=1.75 \times 10^{-5}\right] \tag{7}
\end{equation*}
$$

2.5 Calculate the pH that results after adding 55.00 mL of 0.1572 M NaOH to a buffer consisting of 100.00 mL of $0.5559 \mathrm{M} \mathrm{NH}_{3}$ and 5.815 g of $\mathrm{NH}_{4} \mathrm{Cl}$.
[Molar mass $\left(\mathrm{g} \mathrm{mol}^{-1}\right): \mathrm{NH}_{4} \mathrm{Cl}=53.49 ; \mathrm{K}_{\mathrm{b}}\left(\mathrm{NH}_{3}\right)=1.80 \times 10^{-5}$ ]

## QUESTION 3

3.1 Calculate the number of moles of $\mathrm{I}_{2}$ generated by adding an unmeasured excess of KI to an acidified solution containing $0.05000 \mathrm{~mol}_{\mathrm{KIO}_{3}}$. Base your answer on the two balanced half-reaction equations and the overall balanced reaction equation.
3.2 A volume of 55.00 mL of a $0.1128 \mathrm{M} \mathrm{AgNO}_{3}$ solution was added to 25.00 mL of an NaCl solution, and the excess silver ion then required 10.46 mL of a 0.09834 M KSCN solution to reach the end point. Calculate the \% ( $\mathrm{m} / \mathrm{v}$ ) concentration of the NaCl solution and give the relevant balanced reaction equations for the analysis, but not the indicator reaction equation.
[Molar mass $\left.\left(\mathrm{g} \mathrm{mol}^{-1}\right): \mathrm{NaCl}=58.44\right]$
3.3 Which of the Mohr or Volhard precipitation titrations may be used to determine iodide ion?
3.4 Write an equation for the indicator reaction of the Mohr titration and indicate the colour of the end point.

## QUESTION 4

4.1 Given the following data for the determination of the $\mathrm{MnO}_{4}^{-}$concentration of an unknown solution:

| Solution | $\mathbf{M n O}_{\mathbf{4}}{ }^{-}$concentration <br> $\mathbf{( p p m )}$ | Absorbance at <br> $\mathbf{5 2 5} \mathbf{~ \mathbf { ~ m ~ }}$ |
| :--- | :---: | :---: |
| Standard 1 | 5.00 | 0.150 |
| Standard 2 | 10.00 | 0.300 |
| Standard 3 | 15.00 | 0.450 |
| Unknown | - | 0.375 |

4.1.1 Draw the relevant calibration curve on graph paper and then calculate the concentration of the unknown solution.
4.1.2 In which part of the electromagnetic spectrum does this wavelength lie?
4.1.3 Why did the analyst perform the analysis at the selected wavelength?

## QUESTION 4: (Cont.)

4.2 What do the symbols " $\mathbf{A}$ " and " $\mathbf{a}$ " in the Lambert-Beer law mean?
4.3 Name the two gases used for atomic absorption spectroscopy (AAS), and give the approximate temperature of the flame.
4.4 For the analysis of which compounds would you use:
4.4.1 AAS
(1)
4.4.2 Flame Emission Spectroscopy (FES)

## DATA

$K_{w}=1 \times 10^{-14}$
$\mathrm{pH}=\mathrm{pK}_{\mathrm{a}}+\log \left(\mathrm{C}_{\mathrm{b}} / \mathrm{C}_{\mathrm{a}}\right)=\mathrm{pK} \mathrm{a}_{\mathrm{a}}+\log \left(\mathrm{n}_{\mathrm{b}} / \mathrm{n}_{\mathrm{a}}\right)$
$c=f \times \lambda$
$E=h \times f$
$\mathrm{T}=\mathrm{P}_{\text {out }} / \mathrm{P}_{\text {in }}$
$\% \mathbf{T}=\mathbf{P}_{\text {out }} / \mathbf{P}_{\text {in }} \times \mathbf{1 0 0}$
$A=a \times b \times C$
$A=-\log _{10} T$

