University of Ruhuna - Faculty of Technology

Bachelor of Biosystems Technology

Level 1 (Semester 1) Examination, November 2019

Course Unit: BST 1172 Analytical Chemistry

Time Allowed: 2 hours

*** Answer all four (04) questions** **All symbols have their usual meanings**

01. In each of multiple choice questions I to X, pick one of the alternatives from (*a*), (*b*), (*c*), (*d*), (*e*), which is correct or most appropriate and mark your response on the sheet with a cross (*X*).

I. The weight of a sample is measured as the analytical signal in,
(a) Colorimetry
(b) Conductimetry
(c) Potentiometry
(d) Gravimetry
(e) None of above

II. A portion of 25.00 mL unknown HCl solution was transferred to a titration flask. The solution was titrated with 0.1 mol dm^{-3} NaOH solution suing Phenolphthalein as the indicator. The burette reading at the endpoint was 12.50 mL. The concentration of HCl is,
(a) 1.0 mol dm^{-3}
(b) 0.05 mol dm^{-3}
(c) 0.02 mol dm^{-3}
(d) 0.01 mol dm^{-3}
(e) None of above

III. Following buffer solutions were prepared by dissolving $CH_3COONa_{(s)}$ in 100 mL of $CH_3COOH_{(aq)}$. Which of following buffer solution has the height buffer capacity ?
(a) 0.01 mol dm^{-3} $CH_3COOH_{(aq)}$ / 0.8200 g of $CH_3COONa_{(s)}$
(b) 0.1 mol dm^{-3} $CH_3COOH_{(aq)}$ / 0.8200 g of $CH_3COONa_{(s)}$
(c) 0.1 mol dm^{-3} $CH_3COOH_{(aq)}$ / 8.2000 g of $CH_3COONa_{(s)}$
(d) 0.01 mol dm^{-3} $CH_3COOH_{(aq)}$ / 8.2000 g of $CH_3COONa_{(s)}$
(e) All of above solutions have the same buffer capacity.

IV. Significant figures of the number "1.2500×10^{-4}" is,
(a) 5
(b) 3
(c) 4
(d) 2
(e) None of above

V. Five (05) students in the Department of Biosystems Technology conducted following acid base titration in triplicate. A 10.00 mL portion of 0.1 mol dm^{-3} $HCl_{(aq)}$ solution was transferred to a titration flask and titrated with a solution of 0.1 mol dm^{-3} $NaOH_{(aq)}$. The volumes consumed for the titrations are given below. Which student has obtained the highest accuracy and precision in their results?

(a) 9.80, 9.90, 11.00
(b) 8.50, 8.50, 8.60
(c) 9.80, 9.90, 10.00
(d) 9.00, 10.00, 11.00
(e) 11.00, 11.00, 11.10

VI. A solution of $KOH_{(aq)}$ was prepared by dissolving 2.2400 g of $KOH_{(s)}$ in 400 mL of distilled water. The pH of the solution at 25° C is,

(a) 14
(b) 11
(c) 13
(d) 1
(e) None of these

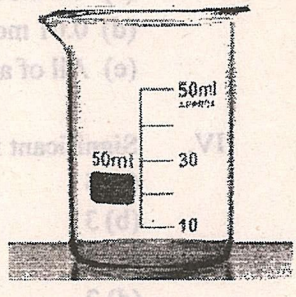
VII. NaA is the salt of weak acid HA. Both NaA and HA are completely soluble in water. The acid dissociation constant of HA is 1.0×10^{-9} mol dm^{-3}. The pH of a solution of 0.1 mol dm^{-3} $NaA_{(aq)}$ is,

(a) 6.0
(b) 7.0
(c) 8.0
(d) 9.0
(e) None of above

VIII. A portion of 10.00 mL of 0.1 mol dm^{-3} $Na_2CO_{3(aq)}$ solution was transferred to a titration flask. The solution was titrated with 0.1 mol dm^{-3} $HCl_{(aq)}$ solution using methyl orange as the indicator. The burette reading at the endpoint is,

(a) 5.00 mL
(b) 10.00 mL
(c) 20.00 mL
(d) 30 mL
(e) None of above

IX. The number of significant figures of the volumes measured by the beaker shown in the picture is,



(a) 1
(b) 2
(c) 3
(d) 4
(e) None of above

X. Which of following solution is an example for buffer solution ?

(a) CH_3COOH/HCl
(b) CH_3COOH/H_2O
(c) $CH_3COOH/NaOH$
(d) HCl/NH_4Cl
(e) None of these

(10 × 10 marks)

2. Answer all parts of the question

(a)

I. Calculate the mass of 0.5 moles of $BaSO_{4(s)}$. (15 marks)

II. Calculate the number of moles of $CaO_{(s)}$ in a sample of 1.1200 g of pure $CaCO_{3(s)}$. (15 marks)

III. Calculate the number of moles of Cl^- in 0.2520 g of $MnCl_{2(s)}$ (15 marks)

IV. Answer following questions regarding thermal decomposition of $NaHCO_3$.

$$NaHCO_{3(s)} \xrightarrow[\Delta]{} Na_2CO_{3(s)} + CO_{2(g)} + H_2O_{(l)}$$

(i) Re-write the balanced chemical reaction for the thermal decomposition of $NaHCO_{3(s)}$. (10 marks)

(ii) If a sample of 8.4000 g of $NaHCO_{3(s)}$ was thermally decomposed completely calculate the weight of remaining solid residue. (15 marks)

(b) Answer following questions.

I. Calculate the amount of $NaOH_{(s)}$ required to prepare a 250.00 mL of 0.05 mol dm^{-3} $NaOH_{(aq)}$ solution. (15 marks)

II. A solution of 0.5 mol dm^{-3} $HCl_{(aq)}$ is available in the laboratory. Calculate the volume of above solution required to prepare a 500.00 mL of 0.025 $HCl_{(aq)}$ solution ? (15 marks)

3. **Answer all parts**

(a) A dilute solution of $HCl_{(aq)}$ is available in the Biosystems Laboratory. A student wants to determine the concentration of the above $HCl_{(aq)}$ solution. In the Biosystems laboratory, $KOH_{(s)}$, $Na_2CO_{3(s)}$, phenolphthalein, methyl orange and distilled water and required glassware are available. The lecturer instructed the student not to use $KOH_{(s)}$ to prepare a primary standard solution. Therefore, student plans to prepare a primary standard solution 0.1 mol dm^{-3} $Na_2CO_{3(s)}$ solution and to carry out the titration.

I. Provide two (02) reasons why KOH is not to be suitable to prepare a primary standard solution. (15 marks)

II. Calculate the amount of $Na_2CO_{3(s)}$ required to prepare 250.00 mL of 0.1 mol dm^{-3} $Na_2CO_{3(aq)}$. (15 marks)

III. A portion of 25.00 mL of 0.1 mol dm^{-3} $Na_2CO_{3(aq)}$ is transferred to a titration flask and titrated with $HCl_{(aq)}$ using methyl orange as the indicator. The burette reading at the end point was 25.00 mL.

(i) What is the color change observed at the end point ?

(ii) Calculate the concentration of $HCl_{(aq)}$ solution.

(iii) Sketch the titration curve of the above titration.

(iv) Sketch the titration curve, if the $Na_2CO_{3(aq)}$ was filled in to the burette in the above titration. (50 marks)

(b) HA is a week acid. The acid dissociation constant of HA at is 1.0×10^{-4} mol dm^{-3}. Answer following questions about 0.01 mol dm^{-3} $HA_{(aq)}$.

I. Calculate $H^+_{(aq)}$ concentration in the solution. (15 marks)

II. Calculate the pH of the solution. (05 marks)

4. **Answer all parts of the question**

(a) Answer following questions about buffer solutions

I. A solution of 1.0 L of 2.0 mol dm^{-3} $CH_3COOH_{(aq)}$ is available in the Biosystems laboratory. Calculate the amount of $CH_3COOH_{(aq)}$ required to be mixed for preparing 1.0 L of buffer solution of pH = 4.75. (15 marks)

II. A student want to prepare 1.0 L of pH = 4.75 buffer solution using 2.0 mol dm^{-3} $CH_3COOH_{(aq)}$. However, $CH_3COONa_{(s)}$ is not available in the Biosystems Laboratory. The lecturer instructed the student to mix $CH_3COOH_{(aq)}$ and $NaOH_{(s)}$ to prepare the buffer solution.

(i) Write down the balanced chemical reaction for the neutralization of $CH_3COOH_{(aq)}$ using NaOH.

(ii) Calculate the amount of $NaOH_{(s)}$ should be mixed with 2.0 mold dm^{-3} $CH_3COOH_{(aq)}$ to prepare 1.0 L of pH = 4.75 buffer solution.

(20 marks)

Note : $CH_3COOH_{(aq)}$ $pK_a = 4.75$

(b) A dilute solution of $KMnO_{4(aq)}$ is available in the laboratory. A portion of 25.0 mL of 0.05 $moldm^{-3}$ $H_2C_2O_{4(aq)}$ solution was transferred to a titration flask. The solution in the titration flask was acidified using Conc. $H_2SO_{4(aq)}$, slightly heated ,and titrated with $KMnO_{4(aq)}$.

I. Write down the balanced chemical reaction for the above titration. (20 marks)

II. Why it is necessary to heat the solution before the titration? (10 marks)

III. Why it is not necessary to heat the solution continuously during the titration? (10 marks)

IV. What is the color change at the end point of the titration ? (10 marks)

V. The end point of the titration was 25.00 mL. Calculate the concentration of $KMnO_{4(aq)}$ solution. (15 marks)

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EKCP

IUPAC Periodic Table of the Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H hydrogen [1.00784, 1.00811]																	2 He helium 4.0026
3 Li lithium [6.938, 6.997]	4 Be beryllium 9.0122											5 B boron [10.806, 10.821]	6 C carbon [12.009, 12.012]	7 N nitrogen [14.006, 14.008]	8 O oxygen [15.999, 16.000]	9 F fluorine 18.998	10 Ne neon 20.180
11 Na sodium 22.990	12 Mg magnesium [24.304, 24.307]											13 Al aluminium 26.982	14 Si silicon [28.084, 28.086]	15 P phosphorus 30.974	16 S sulfur [32.059, 32.076]	17 Cl chlorine [35.446, 35.457]	18 Ar argon 39.948
19 K potassium 39.098	20 Ca calcium 40.078(4)	21 Sc scandium 44.956	22 Ti titanium 47.867	23 V vanadium 50.942	24 Cr chromium 51.996	25 Mn manganese 54.938	26 Fe iron 55.845(2)	27 Co cobalt 58.933	28 Ni nickel 58.693	29 Cu copper 63.546(3)	30 Zn zinc 65.38(2)	31 Ga gallium 69.723	32 Ge germanium 72.630(8)	33 As arsenic 74.922	34 Se selenium 78.971(8)	35 Br bromine [79.901, 79.907]	36 Kr krypton 83.798(2)
37 Rb rubidium 85.468	38 Sr strontium 87.62	39 Y yttrium 88.906	40 Zr zirconium 91.224(2)	41 Nb niobium 92.906	42 Mo molybdenum 95.95	43 Tc technetium	44 Ru ruthenium 101.07(2)	45 Rh rhodium 102.91	46 Pd palladium 106.42	47 Ag silver 107.87	48 Cd cadmium 112.41	49 In indium 114.82	50 Sn tin 118.71	51 Sb antimony 121.76	52 Te tellurium 127.60(3)	53 I iodine 126.90	54 Xe xenon 131.29
55 Cs caesium 132.91	56 Ba barium 137.33	57-71 lanthanoids	72 Hf hafnium 178.49(2)	73 Ta tantalum 180.95	74 W tungsten 183.84	75 Re rhenium 186.21	76 Os osmium 190.23(3)	77 Ir iridium 192.22	78 Pt platinum 195.08	79 Au gold 196.97	80 Hg mercury 200.59	81 Tl thallium [204.38, 204.39]	82 Pb lead 207.2	83 Bi bismuth 208.98	84 Po polonium	85 At astatine	86 Rn radon
87 Fr francium	88 Ra radium	89-103 actinoids	104 Rf rutherfordium	105 Db dubnium	106 Sg seaborgium	107 Bh bohrium	108 Hs hassium	109 Mt meitnerium	110 Ds darmstadtium	111 Rg roentgenium	112 Cn copernicium	113 Nh nihonium	114 Fl flerovium	115 Mc moscovium	116 Lv livermorium	117 Ts tennessine	118 Og oganesson

Key: atomic number / Symbol / name / conventional atomic weight / standard atomic weight

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La lanthanum 138.91	Ce cerium 140.12	Pr praseodymium 140.91	Nd neodymium 144.24	Pm promethium	Sm samarium 150.36(2)	Eu europium 151.96	Gd gadolinium 157.25(3)	Tb terbium 158.93	Dy dysprosium 162.50	Ho holmium 164.93	Er erbium 167.26	Tm thulium 168.93	Yb ytterbium 173.05	Lu lutetium 174.97
89 Ac actinium	90 Th thorium 232.04	91 Pa protactinium 231.04	92 U uranium 238.03	93 Np neptunium	94 Pu plutonium	95 Am americium	96 Cm curium	97 Bk berkelium	98 Cf californium	99 Es einsteinium	100 Fm fermium	101 Md mendelevium	102 No nobelium	103 Lr lawrencium

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For notes and updates to this table, see www.iupac.org. This version is dated 28 November 2016.