

11	a	b	c	d	e
12	a	b	c	d	e
13	a	b	c	d	e
14	a	b	c	d	e
15	a	b	c	d	e
16	a	b	c	d	e
17	a	b	c	d	e
18	a	b	c	d	e
19	a	b	c	d	e
20	a	b	c	d	e

CONFIDENCE LEVELS FOR VARIOUS VALUES OF Z				
CONFIDENCE LEVEL, %	Z			
50	0.67			
68	1.00			
80	1.29			
90	1.64			
95	1.96			
96	2.00			
99	2.58			
99.7	3.00			
Values of t for Various Levels of Probability				
Degrees of Freedom	Factor for Confidence interval,			
	80%	90%	95%	99%
1	3.08	6.31	12.7	63.7
2	1.89	2.92	4.30	9.92
3	1.64	2.35	3.18	5.84
4	1.53	2.13	2.78	4.60
5	1.48	2.02	2.57	4.03
6	1.44	1.94	2.45	3.71
CRITICAL VALUES FOR REJECTION QUOTIENT Q				
Number of Observations	Qcritical			
	90% Confidence	95% Confidence	99% Confidence	
3	0.94	0.98	0.99	
4	0.76	0.85	0.93	
5	0.64	0.73	0.82	
6	0.56	0.64	0.74	
7	0.51	0.59	0.68	
8	0.47	0.54	0.63	

1. An interference or interferent is a substance that
 - a) Exists in the matrix but does not affect the results of analysis
 - b) is used in some methods for analysis of the analyte.
 - c) affects the measured analytical signal for the analyte and leads to error in the analysis results.
 - d) affects taking a sample for analysis.
 - e) None of the above

2. A sample in which the concentration of the analyte is equal to the average concentration of the analyte from the site where the sample is taken is called

- a) Pure sample
- b) Representative sample
- ☒ c) Excellent sample
- d) Replicate sample
- ☐ e) None of the above

3. A 0.3700 g of KCl (molar mass = 74.54 g/mole) is dissolved in 50.00 mL water such that the final volume of the solution is 50.00 mL. Calculate the molar concentration of K^+ in this solution

- a) $1.0 \times 10^{-5} M$
- b) 0.100 M
- c) 0.0500 M
- d) 0.200 M

☒ e) 0.0100 M ✓



$$\frac{0.3700}{74.54}$$

4. A 0.500 M solution of a weak acid HA is known to be 90.0% ionized at this concentration. The equilibrium (or species) concentration of HA in the solution is

- a) 0.550 M
- ☒ b) 0.0500 M
- c) 0.450 M
- d) 0.100 M
- e) 0.900 M



5. A $1.922 \times 10^{-4} M$ $K_3Fe(CN)_6$ (molar mass = 329.115 g/mole) can be expressed in parts per million as

- ☒ a) 63.3 ppm
- b) 45.6 ppm
- c) 29.7 ppm
- d) 77.8 ppm
- e) 37.1 ppm



$$ppm = \frac{\text{mass solute}}{V \text{ solution}}$$

mass sol

$$\boxed{63.3}$$

g →

6. Calculate the molar concentration of Zn^{2+} in a solution that has a pZn value of 3.875

$$10^{-3.875}$$

- a) $7.78 \times 10^{-6} \text{ M}$
- b) $4.45 \times 10^{-3} \text{ M}$
- c) $6.66 \times 10^{-5} \text{ M}$
- ☒ d) $1.33 \times 10^{-4} \text{ M}$
- e) $9.56 \times 10^{-2} \text{ M}$

7. Calculate the molar concentration of concentrated HClO_4 (molar mass = 100.46 g/mole) in a solution that has a specific gravity of 1.67 and is 70.0% HClO_4 (w/w).

$$\frac{1.67 \times 1000 \times 0.70}{100.46}$$

- a) 5.55 M
- ☒ b) 11.6 M
- c) 14.5 M
- d) 9.98 M
- e) 4.78 M

8. In titrations, the color change of a chemical indicator requires an overtitration of 0.04 mL. The type of error in this case is

- a) Gross error
- b) Instrumental error
- ☒ c) Personal error
- d) Method error
- e) Random error

خطأ شخصية
خطأ منهجية
خطأ عشوائية

9. A method of analysis yields weights for gold that are low by 0.4 mg. Calculate the percent relative error caused by this error in the weight of gold in a sample is 45 mg

$$\frac{0.4}{45} \times 100$$

- a) 2.22%
- b) 0.089%
- c) 0.89%
- d) 8.88%
- e) 4.44%

10. Consider the following data obtained for the weight of a sample of natural uranium ores:

0.105, 0.102, 0.106, 0.101, 0.999, 0.100 g

The median for these data is

- a) 0.1050
- b) 0.1010
- c) 0.1020
- ☒ d) 0.1015
- e) 0.1060

11. Independent analysis is a procedure for detection of systematic method error. This procedure involves

- a) Exploration of the dependence of the magnitude of the error on the sample size
- b) Analysis of a standard sample
- ☒ c) Analysis of the sample by a different method
- d) Blank determination
- e) None of the above

12. Random errors

- a) Occur occasionally due to laziness of the experimentalist
- b) Can be determined and compensated for
- c) Can be related to specific perceptible sources
- ☒ d) Are due to combination of small unperceptible errors
- e) None of the above

13. Analysis of several plant-food preparations for potassium ion yielded the following data:

Sample	Percent K ⁺	$\bar{x}$	
1	5.15, 5.03, 5.04	5.07	0.0004 + 0.0016 + 0.0009
2	7.18, 7.17, 6.97	7.11	0.0049 + 0.0036 + 0.0196
3	4.00, 3.93, 4.15	4.03	0.0009 + 0.01 + 0.0144

Calculate a pooled value of the standard deviation, S_{pooled} .

- a) 0.003
b) 0.01
c) 0.1
d) 0.001
e) 0.04

$$\sqrt{\frac{0.0004 + 0.0016 + 0.0009}{6} + \frac{0.0049 + 0.0036 + 0.0196}{6} + \frac{0.0009 + 0.01 + 0.0144}{6}}$$

$$= \sqrt{\frac{0.0029}{6} + \frac{0.0281}{6} + \frac{0.0253}{6}}$$

$$= \sqrt{\frac{0.0563}{6}} = \sqrt{0.00938} = 0.0968$$

14. Estimate the standard deviation in the following calculation and report the result of computation.

$$Y = 90.31(\pm 0.08) - 89.32(\pm 0.06) + 0.200(\pm 0.004)$$

$$S_y =$$

- a) 1(±1)
b) 1.19 (±0.01) ✓
c) 1.2(±0.1)
d) 1.190(±0.001)
e) 1.1900(±0.0001)

$$y = a(\pm a) + b(\pm b)$$

15. Six bottles of orange juice samples were analyzed for residual sugar content with the following results:

No. of samples	6
Average percent concentration of sugar	2.45
Standard deviation	0.03

Calculate the coefficient of variation for the results of analysis.

- a) 0.3%
 b) 0.012
 c) 1.2%
 d) 12.2 ppt (ppt = part per thousand)
 e) 9×10^{-6}

$$\frac{s}{x} \times 100\%$$

$$\frac{0.03}{2.45} \times 100\%$$

16. Perform the following mathematical operation and round the answer so that only the significant figures are retained

$$\log (4.000 \times 10^{-5}) =$$

- a) -4.39790
 b) -4.4
 c) -4.39
 d) -4.398
 e) -4.3979

با داند از لوج
 س.ف. را
 حفظ کنید

17. A chemist determined the percentage of iron in an ore, obtaining the following results: $\bar{x} = 15.30$, $s = 0.10$, $n = 4$. Calculate the 90% confidence limits of the mean for these data.

- a) 15.30 ± 0.33
 b) 15.30 ± 0.29
 c) 15.30 ± 0.16
 d) 15.30 ± 0.41
 e) 15.30 ± 0.12

$$t \frac{s}{\sqrt{n}}$$

$$s = 0.07$$

18. The standard deviation of a method for determining manganese in steel is known from a large number of determinations to be 0.07. How many determinations must be run by this method if the 90% confidence interval of the mean is to be ± 0.06 ?

- a) 12
- b) 2
- c) 4
- d) 6
- e) 9

$$\frac{z \cdot s}{\sqrt{n}} = 0.06$$

$$0.06 = \frac{1.64 \cdot 0.07}{\sqrt{n}}$$

19. Apply the Q-test to the following data to determine which result should be rejected at the 95% confidence level 7.295, 7.284, 7.388, 7.292.

- a) 7.292
- b) 7.295
- c) 7.388
- d) 7.284

e) none of the results should be rejected.

$$7.284 / 7.292 / 7.295 / 7.388$$

20. The confidence interval is an interval around the experimental mean within which:

- a) the true value exists.
- b) the population mean exists within $\pm \sigma$ bounds
- c) the population mean exists within $\pm 2\sigma$ bounds
- d) the population mean exists with a certain probability
- e) the population mean exists with 100% probability.

THE END THE END THE END

نجاحي هو قمره
اجتهادي ش

11-10 2.0.2

مبارك

11
15

Analytical Chemistry
First Exam -

Name: علاء محمد الملا Date: 20/3/2012

Reg. No.: ... 0101200 ... Seat no.:

Section: 1 2 3 4

1. a b c d ☒ 9. ☒ ☒ c d e
2. ☒ b c d e 10. a b c d ☒
3. ☒ ☒ c d e 11. ☒ b c d e
4. a b c d ☒ 12. a b c ☒ e
5. a ☒ c d e 13. a b c d ☒
6. a b ☒ d e 14. a b ☒ ☒ e
7. ☒ b c d e 15. a ☒ c d e
8. a ☒ c d ☒

GOOD LUCK

اتحاد طلبة العلوم الحياتية 2012

غيرنا وحسنه *

$$\mu = \frac{M_1 U_1}{M_2 U_2} \quad M_1 U_1 = M_2 U_2$$

$$d = \frac{M \times M_w}{V \times 10} = \frac{20.24 \times 40}{10 \times 53.4} = \frac{809.6}{534} = 1.52$$

1. What is the density of 53.4 wt % aqueous NaOH (MW = 40.00) if 16.7 mL of the solution diluted to 2.00 L gives 0.169 M NaOH.

- a) 15.2g/mL b) 0.169g/mL c) 3.03g/mL d) 0.75g/mL **e) 1.52 g/mL**

2. 500 mL of a water sample is found to contain 0.0014 g of CaCO₃ (molar mass 100.1 g/mol). Calculate the concentration of CaCO₃ in parts per million.

- a) 2.8 ppm** b) 0.0014ppm c) 1.4 ppm d) 0.028 ppm e) 0.14 ppm

3. What volume of water should be added to 10.0 mL of a 0.500 M solution of NaCl to make the molarity 0.200M. Assume volumes are additive.

- a) 25 mL** b) 15 mL c) 40mL d) 10mL e) 5mL

4. The molarity of an NaOH solution was determined by titration vs. KHP. Individual titrations gave the following concentrations: 0.1127M, 0.1112M, 0.1132M, 0.1134M and 0.1174M. Which of these points should be rejected at the 95% confidence interval?

- a) 0.1127 **b) 0.1112** c) 0.1174 d) 0.1134 **e) none of the above.**

5. This particular analysis (in question 4) has been performed thousands of times - enough such that the population standard deviation (S) can be determined. Assuming that S is equal to 0.0003M for this determination, calculate the 95% confidence interval for μ

- a) 0.1136 ± 0.00026 **b) 0.1136 ± 0.0003** c) 0.114 ± 0.0003
d) 0.114 ± 0.00026 e) 0.1126 ± 0.0003

6. For the following calculations, determine the answer and the appropriate uncertainty:

$$15.4(\pm 0.3) - 7.0(\pm 0.4)$$

- a) 8.4 ± 0.7 b) 8.4 ± 0.1 **c) 8.4 ± 0.5** d) 8.40 ± 0.70 e) 8.40 ± 0.50

7. For the following calculations, determine the answer and the appropriate uncertainty:

$$\text{antilog } 6.44 \pm 0.04$$

- a) (2.8 ± 0.3) × 10⁶** b) 2.8 × 10⁶ c) (2.80 ± 0.3) × 10⁶
d) 2.80 × 10⁶ e) (2.80 ± 0.30) × 10⁶

$$\begin{aligned} 10.0\% & \leftarrow 2 \\ 0.4\% & \leftarrow 0.1 \\ \frac{0.4 \times 10^{-3} \times 100\%}{0.1} & = 0.4\% \rightarrow 10.0\% - 4\% \end{aligned}$$

8. In a certain method for determining silica, SiO_2 is precipitated and weighed. It is found that the amount of SiO_2 obtained is always 0.4 mg too high regardless of the weight of sample taken for analysis. Calculate the % error in a sample which contains 10.0% SiO_2 if the sample analyzed is 0.100 g.

- a) 40% **b) 0.4%** c) 10% d) 0.04% e) 4%

$$\begin{aligned} \% \text{ error} &= \frac{x_1 - x_2}{x_2} \times 100\% \\ &= \frac{0.4}{0.1} \times 100\% = 400\% \\ 10.0\% \times 4 &= 40\% \end{aligned}$$

9. Titrator A obtains a mean value of 24.32% and a standard deviation of 0.12 for the purity of a compound. Titrator B obtains corresponding values of 24.52% and 0.10. The true value is 24.40 %. Compared with titrator B, titrator A is:

- a) less accurate but more precise ✓
b) more accurate and less precise ✓
c) less accurate and less precise
d) more accurate but more precise
e) no information about accuracy and precision could be obtained from the given information.

$$\begin{aligned} \text{RSD} &= \frac{x_1 - x_2}{x_2} = \frac{24.32 - 24.40}{24.40} = \frac{-0.08}{24.40} = -0.00327 \\ \text{RSD} &= \frac{24.52 - 24.40}{24.40} = \frac{0.12}{24.40} = 0.0049 \\ \text{RSD} &\downarrow \text{more precise} \end{aligned}$$

10. Calculate the pH of a 0.050 M solution of acetic acid. The K_a of acetic acid is 1.8×10^{-5} .

- a) 4.50 b) 0.65 c) 5.05 d) 7.00 **e) 3.02**

$$\begin{aligned} H^+ &= \sqrt{K_a C} = \sqrt{1.8 \times 10^{-5} \times 0.05} = \sqrt{0.9 \times 10^{-6}} \\ &= 0.95 \times 10^{-3} = 9.5 \times 10^{-4} \\ \text{pH} &= 4 - \text{pH} = 3.02 \end{aligned}$$

11. Calculate the pH of a solution that is 0.10 M in sodium acetate. K_a for acetic acid is 1.8×10^{-5} :

- a) 8.88** b) 1.00 c) 7.00 d) 5.2 e) 9.30

$$\begin{aligned} \text{pH} &= \frac{14 - \text{pH}}{1.8 \times 10^{-5}} = 0.56 \times 10^{-9} \\ &= \sqrt{\frac{0.05 \times 10^{-9}}{0.56 \times 10^{-10}}} \\ \text{pH} &= 0.75 \times 10^{-6} = 7.5 \times 10^{-6} \\ \text{pH} &= 5.72 \end{aligned}$$

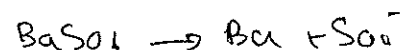
12. The solubility of silver chromate (molar mass 332 g/mol) at 25°C is 0.0279 g/L. Calculate the value of K_{sp} for Ag_2CrO_4 .

- a) 2.9×10^{-8} b) 1.1×10^{-12} c) 7.8×10^{-4} **d) 2.4×10^{-12}** e) 5.9×10^{-13}

$$\begin{aligned} K_{sp} &= [\text{Ag}^+]^2 [\text{CrO}_4^{2-}] \\ &= (2 \times 8.4 \times 10^{-5})^2 (8.4 \times 10^{-5}) \\ &= 141.12 \times 10^{-15} = 2.32 \times 10^{-12} \\ \text{pH} &= 8.88 \end{aligned}$$

13. Consider the dissociation of barium sulfate (BaSO_4 ; $K_{sp} = 1.1 \times 10^{-10}$). Calculate the molar solubility of BaSO_4 in water:

- a) $1.0 \times 10^{-3} \text{ M}$ b) $1.1 \times 10^{-10} \text{ M}$ c) $1.0 \times 10^{-6} \text{ M}$ d) $7.0 \times 10^{-5} \text{ M}$ **e) $1.0 \times 10^{-5} \text{ M}$**



$$\begin{aligned} K_{sp} &= 1.1 \times 10^{-10} \\ \sqrt{x^2} &= \sqrt{1.1 \times 10^{-10}} \\ &= 1.05 \times 10^{-5} \end{aligned}$$

14. Calculate the pH of a solution prepared by mixing 100 mL of 0.05 M NaOH with 100 mL of 0.175M acetic acid (CH_3COOH). K_a for CH_3COOH is 1.8×10^{-5} $K_b = 0.56 \times 10^{-9}$

- a) 1.3 b) 12.7 c) 4.4 **(d) 9.6** e) 7.0

15. Which of the following solutions is the most acidic solution:

- a) $\text{pH} = 10$ **(b) $[\text{OH}^-] = 10^{-12} \text{ M}$** c) $\text{pH} = 5$ d) $[\text{H}_3\text{O}^+] = 10^{-6} \text{ M}$ e) $\text{pOH} = 7$

$K^+ = 10^{-2}$
 $\text{pH} = 2$

NaOH

$M = 0.05$

$V = 100 \text{ ml}$

$n = 0.005$

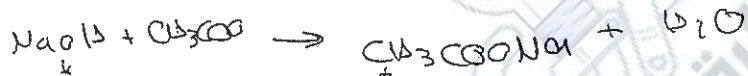
lim

limiting

CH_3COOH $K_a = 1.8 \times 10^{-5}$
 $M = 0.175$
 $V = 100 \text{ ml}$
 $n = 0.0175$

0.005

basic



$1 \rightarrow 1$
 $0.005 \rightarrow 0.005$

$\text{pH} = \sqrt{\text{p}K}$

$\text{pOH} = \sqrt{K_b \times [\text{Salt}]}$

$0.56 \times 10^{-9} \times [0.005]$

$n \text{ CH}_3\text{COONa} = 0.005$

$M = \frac{0.005}{200 \text{ ml}}$

$= \frac{0.005}{0.2}$

$= 0.025$

0.014×10^{-9}

0.14×10^{-10}

$\text{pOH} = 0.37 \times 10^{-5}$

$\text{pH} = 3.7 \times 10^{-6}$

$\text{pOH} = 5.43$

$\text{pH} = 8.58$

Activity Coefficients for Ions at 25 °C

Ion	Activity Coefficient at Indicated Ionic Strength					
	$\alpha_{\infty}, \text{nm}$	0.001	0.005	0.01	0.05	0.1
H_3O^+	0.9	0.967	0.934	0.913	0.85	0.83
$\text{Li}^+, \text{C}_6\text{H}_5\text{COO}^-$	~0.6	0.966	0.930	0.907	0.83	0.80
$\text{Na}^+, \text{IO}_3^-, \text{HSO}_3^-, \text{HCO}_3^-, \text{H}_2\text{PO}_4^-, \text{H}_2\text{AsO}_4^-, \text{OAc}^-$	0.4-0.45	0.965	0.927	0.902	0.82	0.77
$\text{OH}^-, \text{F}^-, \text{SCN}^-, \text{HS}^-, \text{ClO}_3^-, \text{ClO}_4^-, \text{BrO}_3^-, \text{IO}_4^-, \text{MnO}_4^-$	0.35	0.965	0.926	0.900	0.81	0.76
$\text{K}^+, \text{Cl}^-, \text{Br}^-, \text{I}^-, \text{CN}^-, \text{NO}_2^-, \text{NO}_3^-, \text{HCOO}^-$	0.3	0.965	0.925	0.899	0.81	0.75
$\text{Rb}^+, \text{Cs}^+, \text{Tl}^+, \text{Ag}^+, \text{NH}_4^+$	0.25	0.965	0.925	0.897	0.80	0.75
$\text{Mg}^{2+}, \text{Be}^{2+}$	0.8	0.872	0.756	0.690	0.52	0.44
$\text{Ca}^{2+}, \text{Cu}^{2+}, \text{Zn}^{2+}, \text{Sn}^{2+}, \text{Mn}^{2+}, \text{Fe}^{2+}, \text{Ni}^{2+}, \text{Co}^{2+}, \text{Phthalate}^{2-}$	0.6	0.870	0.748	0.676	0.48	0.40
$\text{Sr}^{2+}, \text{Ba}^{2+}, \text{Cd}^{2+}, \text{Hg}^{2+}, \text{S}^{2-}$	0.5	0.869	0.743	0.668	0.46	0.38
$\text{Pb}^{2+}, \text{CO}_3^{2-}, \text{SO}_4^{2-}, \text{C}_2\text{O}_4^{2-}$	0.45	0.868	0.741	0.665	0.45	0.36
$\text{Hg}_2^{2+}, \text{SO}_3^{2-}, \text{S}_2\text{O}_3^{2-}, \text{Cr}_2\text{O}_7^{2-}, \text{HPO}_4^{2-}$	0.40	0.867	0.738	0.661	0.44	0.35
$\text{Al}^{3+}, \text{Fe}^{3+}, \text{Cr}^{3+}, \text{La}^{3+}, \text{Ce}^{3+}$	0.9	0.737	0.540	0.443	0.24	0.18
$\text{PO}_4^{3-}, \text{Fe}(\text{CN})_6^{3-}$	0.4	0.726	0.505	0.394	0.16	0.095
$\text{Th}^{4+}, \text{Zr}^{4+}, \text{Ce}^{4+}, \text{Sn}^{4+}$	1.1	0.587	0.348	0.252	0.10	0.063
$\text{Fe}(\text{CN})_6^{4-}$	0.5	0.569	0.305	0.200	0.047	0.020

Confidence Levels for Various Values of z

Confidence Level, %	z
50	0.67
68	1.00
80	1.28
90	1.64
95	1.96
95.4	2.00
99	2.58
99.7	3.00
99.9	3.29

Values of t for Various Levels of Probability

Degrees of Freedom	80%	90%	95%	99%	99.9%
1	3.08	6.31	12.7	63.7	637
2	1.89	2.92	4.30	9.92	31.6
3	1.64	2.35	3.18	5.84	12.9
4	1.53	2.13	2.78	4.60	8.61
5	1.48	2.02	2.57	4.03	6.87
6	1.44	1.94	2.45	3.71	5.96
7	1.42	1.90	2.36	3.50	5.41
8	1.40	1.86	2.31	3.36	5.04
9	1.38	1.83	2.26	3.25	4.78
10	1.37	1.81	2.23	3.17	4.59
15	1.34	1.75	2.13	2.95	4.07
20	1.32	1.73	2.09	2.84	3.85
40	1.30	1.68	2.02	2.70	3.55
60	1.30	1.67	2.00	2.62	3.46
∞	1.28	1.64	1.96	2.58	3.29

Critical Values for the Rejection Quotient, Q^*

Number of Observations	Q_{crit} (Reject if $Q > Q_{crit}$)		
	90% Confidence	95% Confidence	99% Confidence
3	0.941	0.970	0.994
4	0.765	0.829	0.926
5	0.642	0.710	0.821
6	0.560	0.625	0.740
7	0.507	0.568	0.680
8	0.468	0.526	0.634
9	0.437	0.493	0.598
10	0.412	0.466	0.568

$N=5$
 $C=95\%$
 $Q_{cal} = 0.65$
 $Q_{crit} = 0.710$

$Q_{cal} < Q_{crit}$
 ret. val.

يطلب اللب ... فلا تحزن
طالب طين طين طين

12/15

طار فياض
ع. ش. ع
10-11

Analytical Chemistry
Second Exam

Name: Date: 30/4/2012

Reg. No.: 0101200 Seat no.:

Section: 1 2 3 4

1. a b ☒ d e 9. a b c d ☒
2. ☒ b c d e 10. a b ☒ d e
3. a b c ☒ e 11. ☒ b c d e
4. a b ☒ d e 12. a ☒ c d e
5. a b ☒ d e 13. a b c ☒ e
6. a ☒ c d e 14. a ☒ c d e
7. a ☒ c d e 15. ☒ b c d e
8. a ☒ c d e

GOOD LUCK

اتحاد طلبة العلوم الحياتية 2012

غيرنا حصل

$$\frac{8.1 \times 10^{-19}}{0.82 \times 0.81} = [Cu] [Cl] \quad C_{u_8} = 0.82$$

$$\frac{8.1 \times 10^{-20}}{0.65^{112}} = Ca^{2+} \quad Cl^- = 0.81$$

$$\sqrt{21.95 \times 10^{-20}} = Ca^{2+} \quad Ca^{2+} = 11.04 \times 10^{-10}$$

$$= \frac{1}{2} (0.05 \times 1 + 0.05) \quad \frac{1}{2} C \quad 0.05$$

$$K_{sp} = [Cu] [Cl]$$

$$Ca^{2+} = \sqrt{8.1 \times 10^{-19}}$$

$$Ca = 9 \times 10^{-10}$$

1. Calculate the % relative error in solubility calculation of CuCl in 0.05M KNO₃ when using molarities instead of activities. For CuCl $K_{sp} = 8.1 \times 10^{-19}$

- a) -46 % b) +36% **c) -18%** d) +18% e) -36%

2. A correct mass-balance equation for a solution saturated with CaC₂O₄ is:-

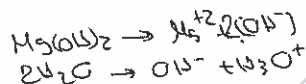
a) $[Ca^{2+}] = [C_2O_4^{2-}] + [HC_2O_4^-] + [H_2C_2O_4]$ ✓

b) $2[Ca^{2+}] + [H_3O^+] = 2[C_2O_4^{2-}] + [OH^-]$

c) $[Ca^{2+}] + [H_3O^+] = 2[C_2O_4^{2-}] + [OH^-] \times$

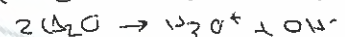
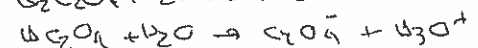
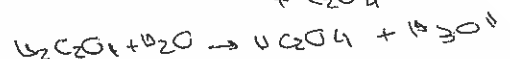
d) $2[Ca^{2+}] + [H_3O^+] = [C_2O_4^{2-}] + [OH^-] \times$

e) $[Ca^{2+}] = [C_2O_4^{2-}]$



$$\frac{9 \times 10^{-10} - 11.04 \times 10^{-10}}{11.04 \times 10^{-10}}$$

$$CaC_2O_4 \rightarrow Ca^{2+} + C_2O_4^{2-} \quad -18.48\%$$



3. Calculate the molar solubility of Mg(OH)₂ ($K_{sp} = 7.1 \times 10^{-12}$) in water.

- a) 7.1×10^{-12} M b) 2.4×10^{-14} M c) 4.1×10^{-11} M **d) 1.2×10^{-4} M**

e) 8.0×10^{-18} M

$$K_{sp} = [Mg^{2+}] [OH^-]^2 = 7.1 \times 10^{-12}$$

$$K_{sp} = [Mg^{2+}] [OH^-]^2 = 1 \times 10^{-14}$$

$$OH^- = 2[Mg^{2+}] + [H_3O^+]$$

4. Generation of hydroxide ion as a precipitating agent from urea for the purpose of precipitating Fe³⁺ as Fe(OH)₃ is called:

- a) peptization
b) coagulation
c) precipitation from homogeneous solution.
d) digestion of the precipitate
e) coprecipitation

$$OH^- = 2[Mg^{2+}]$$

$$K_{sp} = [Fe^{3+}] [OH^-]^3$$

$$\frac{7.1 \times 10^{-12}}{4} = \frac{4}{4} [Mg^{2+}]^3$$

$$Mg^{2+} = \sqrt[3]{1.775 \times 10^{-12}}$$

$$Mg^{2+} = 1.21 \times 10^{-4}$$

5. An aqueous solution contains NaNO₃ and KBr. The bromide ion was separated as AgBr by addition of excess precipitating agent AgNO₃. The charge on the surface of the primary adsorption layer of the colloidal precipitate is

- a) Positive charge due to the adsorption of potassium ions
b) Negative charge due to the adsorption of nitrate ions
c) Positive charge due to the adsorption of silver ions ✓
d) Negative charge due to the adsorption of bromide ions.
e) Neutral since primary adsorption layer will neutralize the counter ions

6. Which of the following statements is correct:

- a) Peptization is heating the precipitate in solution to coagulate the precipitate. ~~X~~
- ☒ b) Inclusion or mixed crystal formation occurs in case of colloidal precipitates. ~~X~~
- c) Coprecipitation is bringing down with the precipitate substance which are normally soluble. ~~X~~
- d) Colloidal precipitates are best washed with distilled water. ~~X~~
- e) Occlusion is replacing some ions in the crystal by foreign ions. ~~X~~

7. A sample of pure sodium oxalate, $\text{Na}_2\text{C}_2\text{O}_4$, weighing 0.2856 g (molar mass 134 g/mol) is dissolved in water, sulfuric acid is added, and the solution is titrated at 70°C , requiring 45.12 mL of a KMnO_4 solution. The end point is overrun and back-titration is carried out with 1.78 mL of 0.0516 M solution of oxalic acid. Calculate the molarity of the KMnO_4 solution.

Equation is:



- a) 0.048 M ☒ b) 0.0197 M c) 0.0394 M d) 0.009 M e) 0.018 M

8. In the titration 50.0 mL 0.1 M NaCl with 0.1 M AgNO_3 , calculate pCl after addition of 50.0 mL AgNO_3 .

K_{sp} for $\text{AgCl} = 1 \times 10^{-10}$

- a) 6.00 ☒ b) 5.00 c) 7.5 d) 7.00 e) 9.00

9. Chloride ions are to be determined by titration in a solution of pH 1.5. Which method would give the best results:-

- a) Mohr's method using K_2CrO_4 indicator. ~~X~~
- b) Fajan's method using dichlorofluorescein indicator. ~~X~~
- c) Titration with EDTA. ~~X~~
- d) Titration with HCl . ~~X~~
- ☒ e) Back titration using Volhard's method in which Fe^{3+} indicator is used.

$$\Delta G = \frac{1.8 \times 10^{-10}}{0.1} = 1.8 \times 10^{-9}$$

10. Iodide ions are to be separated from chloride ions as silver salts in a solution containing 0.10 M of each ion. Given that K_{sp} for $AgCl = 1.8 \times 10^{-10}$, K_{sp} for $AgI = 7.3 \times 10^{-17}$ and using 1×10^{-5} M as a criterion for quantitative precipitation, which of the following statements is correct:-

- a) separation is not feasible. ✗
 b) I^- can be separated if $[Ag^+]$ is less than 7.3×10^{-12} M. ✗
 c) I^- can be separated from Cl^- if $[Ag^+]$ is held between 7.3×10^{-12} - 1.8×10^{-9} M. ✓
 d) $AgCl$ will precipitate if $[Ag^+] = 7.3 \times 10^{-10}$ M.
 e) Both Cl^- and I^- will precipitate at $[Ag^+] 7.3 \times 10^{-12}$ - 1.8×10^{-9} M.

$\Delta G I$ pre first
 $I^- = 1 \times 10^{-5}$
 $7.3 \times 10^{-17} = [Ag^+] \times \frac{10^{-5}}{10^{-5}}$
 $[Ag^+] = 7.3 \times 10^{-12}$

11. Calculate the pH of a solution that is 0.1 M of each $Fe(III)$ and $Mg(II)$, in which $Fe(III)$ is needed to be separated quantitatively from the $Mg(II)$ as hydroxide. Given that

K_{sp} for $Fe(OH)_3 = 5 \times 10^{-39}$

K_{sp} for $Mg(OH)_2 = 7.1 \times 10^{-12}$

Using 1×10^{-6} M as criterion for quantitative removal of ions

- a) 3.23 b) 8.92 c) 5.07 d) 10.77 e) 2.47

$OH^- = \sqrt[3]{\frac{5 \times 10^{-39}}{0.1}} = \sqrt[3]{5 \times 10^{-39}} = 3.68 \times 10^{-13}$
 $OH^- = \sqrt{\frac{7.1 \times 10^{-12}}{0.1}} = \sqrt{7.1 \times 10^{-11}} = 8.42 \times 10^{-6}$
 $OH^- = \sqrt[3]{\frac{5 \times 10^{-39}}{1 \times 10^{-6}}} = 1.7 \times 10^{-11}$

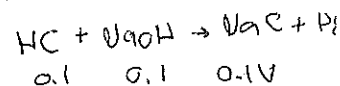
$OH^- = 1.7 \times 10^{-11}$
 $pH = 3.23$

12. 0.10M solution of an acid HC ($pK_a = 4.30$) is titrated with 0.10 M NaOH, which is the most suitable indicator for this titration:

Indicator	pK_{in}
I (acid)	8
II (base)	5
III (acid)	10

- a) I b) II c) III d) I or II e) II or III

$pH = pK_a \pm 1$
 $pH = 4.3 \pm 1$
 $pH = 3.3 - 5.3$



$[OH^-] = \sqrt{\frac{K_b}{K_a} \times \frac{0.1}{2}}$

$pK_a = -\log [K_a] = 4.3$

$K_a = 5.0 \times 10^{-5}$

$pH = pK_a \pm 1$

$VC = \sqrt{0.1 \times 5.0 \times 10^{-5}} = 2.2 \times 10^{-3}$

0.15
 0.1

$$[H_3O^+] = \frac{n_{HCl} - n_{NaOH}}{V} = \frac{3.6 - 3}{70} = 8.57 \times 10^{-3}$$

2.07

Strong - 36 eq. H^+

13. 40.00 mL of 0.0900 M HCl is titrated with 0.1 M NaOH. Calculate the pH after addition of 30.00 mL of NaOH

a) 1.82 b) 2.34 c) 1.51 **d) 2.07** e) 0.09

14. In the titration of 40.00 mL of 0.110 M NOCl (K_a for HOCl = 6.25×10^{-10}) with 0.100 M HCl. Calculate the pH after addition of 44.00 mL HCl.

a) 6.38 **b) 5.24** c) 4.00 d) 3.21 e) 8.76

15. Which of the following acids would show the sharpest end point when 50.00 mL of 0.10M of the acid is titrated with 0.10 M NaOH:

- a) Acid I with $K_a = 1 \times 10^{-2}$
 b) Acid II with $K_a = 1 \times 10^{-4}$
 c) Acid III with $K_a = 1 \times 10^{-6}$
 d) Acid IV with $K_a = 1 \times 10^{-8}$
 e) Acid V: very strong acid

very strong acid is true.

$$[H_3O^+] = \sqrt{K_a \cdot \frac{n_{HCl}}{V_{tot}}}$$

$$= \sqrt{6.25 \times 10^{-10} \times \frac{4.4 \times 10^{-3}}{84 \times 10^{-3}}}$$

$$= 0.57 \times 10^{-5}$$

$$[H_3O^+] = 5.7 \times 10^{-6}$$

$$= 5.24$$

Activity Coefficients for Ions at 25°C

Ion	$\alpha_{\gamma}, \text{nm}$	Activity Coefficient at Indicated Ionic Strength				
		0.001	0.005	0.01	0.05	0.1
H ₃ O ⁺	0.9	0.967	0.934	0.913	0.85	0.81
Li ⁺ , C ₆ H ₅ COO ⁻	~0.6	0.966	0.930	0.907	0.83	0.80
Na ⁺ , IO ₃ ⁻ , HSO ₃ ⁻ , HCO ₃ ⁻ , H ₂ PO ₄ ⁻ , H ₂ AsO ₄ ⁻ , OAc ⁻ , <u>Ca²⁺</u>	0.4-0.45	0.965	0.927	0.902	<u>0.82</u>	0.77
OH ⁻ , F ⁻ , SCN ⁻ , HS ⁻ , ClO ₃ ⁻ , ClO ₄ ⁻ , BrO ₃ ⁻ , IO ₄ ⁻ , MnO ₄ ⁻	0.35	0.965	0.926	0.900	0.81	0.76
K ⁺ , Cl ⁻ , Br ⁻ , I ⁻ , CN ⁻ , NO ₂ ⁻ , NO ₃ ⁻ , HCOO ⁻	0.3	0.965	0.925	0.899	<u>0.81</u>	0.75
Rb ⁺ , Cs ⁺ , Tl ⁺ , Ag ⁺ , NH ₄ ⁺	0.25	0.965	0.925	0.897	0.80	0.75
Mg ²⁺ , Be ²⁺	0.8	0.872	0.756	0.690	0.52	0.44
Ca ²⁺ , Cu ²⁺ , Zn ²⁺ , Sr ²⁺ , Mn ²⁺ , Fe ²⁺ , Ni ²⁺ , Co ²⁺ , Phthalate ²⁻	0.6	0.870	0.748	0.676	0.48	0.40
Sr ²⁺ , Ba ²⁺ , Cd ²⁺ , Hg ²⁺ , S ²⁻	0.5	0.869	0.743	0.668	0.46	0.38
Pb ²⁺ , CO ₃ ²⁻ , SO ₄ ²⁻ , C ₂ O ₄ ²⁻	0.45	0.868	0.741	0.665	0.45	0.36
Hg ₂ ²⁺ , SO ₃ ²⁻ , S ₂ O ₃ ²⁻ , Cd ²⁺ , HPO ₄ ²⁻	0.40	0.867	0.738	0.661	0.44	0.35
Al ³⁺ , Fe ³⁺ , Cr ³⁺ , La ³⁺ , Ce ³⁺	0.9	0.737	0.540	0.443	0.24	0.18
PO ₄ ³⁻ , Fe(CN) ₆ ³⁻	0.4	0.726	0.505	0.394	0.16	0.095
Th ⁴⁺ , Zr ⁴⁺ , Ce ⁴⁺ , Sn ⁴⁺	1.1	0.587	0.348	0.252	0.10	0.063
Fe(CN) ₆ ⁴⁻	0.5	0.569	0.305	0.200	0.047	0.020

Confidence Levels for Various Values of z

Confidence Level, %	z
50	0.67
68	1.00
80	1.28
90	1.64
95	1.96
95.4	2.00
99	2.58
99.7	3.00
99.9	3.29

Values of t for Various Levels of Probability

Degrees of Freedom	80%	90%	95%	99%	99.9%
1	3.08	6.31	12.7	63.7	637
2	1.89	2.92	4.30	9.92	31.6
3	1.64	2.35	3.18	5.84	12.9
4	1.52	2.13	2.78	4.60	8.61
5	1.48	2.02	2.57	4.03	6.87
6	1.44	1.94	2.45	3.71	5.96
7	1.42	1.90	2.36	3.50	5.41
8	1.40	1.86	2.31	3.36	5.04
9	1.38	1.83	2.26	3.25	4.78
10	1.37	1.81	2.23	3.17	4.59
15	1.34	1.75	2.13	2.95	4.07
20	1.32	1.73	2.09	2.84	3.85
30	1.30	1.68	2.02	2.70	3.55
60	1.30	1.67	2.00	2.62	3.46
∞	1.28	1.64	1.96	2.58	3.29

Critical Values for the Rejection Quotient, Q*

Number of Observations	Q _{crit} (Reject if Q > Q _{crit})		
	90% Confidence	95% Confidence	99% Confidence
3	0.941	0.970	0.994
4	0.765	0.829	0.926
5	0.642	0.719	0.821
6	0.560	0.625	0.740
7	0.507	0.568	0.680
8	0.468	0.526	0.634
9	0.437	0.493	0.598
10	0.412	0.466	0.568

Name.....

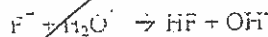
0101200

1. Which of the following sentences is not correct?

- As a solution approaches infinite dilution, the activity coefficient approaches 1. ✓
- Activity coefficient of an uncharged molecule is approximately unity regardless of ionic strength. ✓
- In a solution that is not too concentrated, the activity coefficient of a given ion is independent of the nature of the electrolyte and dependent only on the ionic strength. ✓
- At any given ionic strength, the activity coefficient of ions of the same charge are approximately equal. ✓
- For a given ionic strength, the activity coefficient of an ion becomes closer to unity as the charge carried by the ion increases. ✓

2. Which is the mass-balanced equation for a saturated solution of CaF_2 ?

Useful equations:



$$C_{\text{Ca}^{2+}} = \frac{1}{2} [\text{F}^-] + [\text{HF}]$$

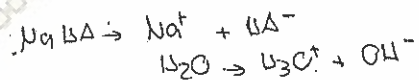
$$[\text{Ca}] = \frac{1}{2} [\text{F}^-]$$

$$[\text{F}^-] = C_{\text{HF}}$$

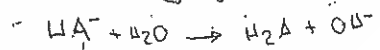
- $[\text{Ca}^{2+}] = \frac{1}{2} \{ [\text{F}^-] - [\text{HF}] \}$
- $[\text{Ca}^{2+}] = \frac{1}{2} \{ [\text{F}^-] + [\text{HF}] \}$
- $[\text{Ca}^{2+}] = 2[\text{F}^-] + [\text{HF}]$
- $[\text{Ca}^{2+}] = 2[\text{F}^-] - [\text{HF}]$
- All of the above

3. Write down the charge - balance equation for a solution containing 0.10 M NaHA

- $[\text{Na}^+] = [\text{HA}^-] + 2[\text{A}^{2-}] + [\text{OH}^-]$
- $[\text{Na}^+] + [\text{H}_3\text{O}^+] = [\text{HA}^-] + 2[\text{A}^{2-}] + [\text{OH}^-]$
- $[\text{Na}^+] = [\text{HA}^-]$
- $[\text{Na}^+] + [\text{H}_3\text{O}^+] = [\text{HA}^-] + [\text{A}^{2-}] + [\text{OH}^-]$
- $2[\text{Na}^+] + [\text{H}_3\text{O}^+] = [\text{HA}^-] + 2[\text{A}^{2-}] + [\text{OH}^-]$



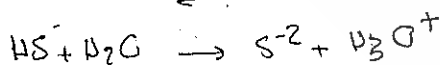
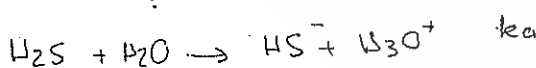
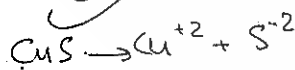
$$[\text{Na}^+] + [\text{H}_3\text{O}^+] = [\text{HA}^-] + 2[\text{A}^{2-}] + [\text{OH}^-]$$



4. Calculate the molar solubility of CuS in a solution in which the $[\text{H}_3\text{O}^+]$ is held constant at

$2.0 \times 10^{-1} \text{ M}$. K_{sp} for CuS is 8×10^{-37} , and for H_2S $K_1 = 9.6 \times 10^{-8}$ and $K_2 = 1.3 \times 10^{-14}$.

- $4 \times 10^{-4} \text{ M}$
- $5.1 \times 10^{-9} \text{ M}$
- $3.2 \times 10^{-3} \text{ M}$
- $3.4 \times 10^{-23} \text{ M}$
- $3.5 \times 10^{-12} \text{ M}$



$$[\text{Cu}^{2+}] = [\text{S}^{2-}] + [\text{HS}^-] + [\text{H}_2\text{S}]$$

$$= [\text{S}^{2-}] + \frac{[\text{S}^{2-}][\text{H}_3\text{O}^+]^2}{K_1 K_2} + \frac{[\text{S}^{2-}][\text{H}_3\text{O}^+]^2}{K_1 K_2}$$

$$= [\text{S}^{2-}] \left(1 + \frac{0.04}{12.48 \times 10^{-22}} + \frac{0.2}{1.3 \times 10^{-14}} \right)$$

$$K_{\text{sp}} = [\text{Cu}^{2+}][\text{S}^{2-}] = 8 \times 10^{-37}$$

$$K_{a1} = \frac{[\text{HS}^-][\text{H}_3\text{O}^+]}{[\text{H}_2\text{S}]}$$

$$[\text{H}_2\text{S}] = \frac{[\text{HS}^-][\text{H}_3\text{O}^+]}{K_{a1}}$$

$$K_{a2} = \frac{[\text{S}^{2-}][\text{H}_3\text{O}^+]}{[\text{HS}^-]}$$

$$[\text{HS}^-] = \frac{[\text{S}^{2-}][\text{H}_3\text{O}^+]}{K_{a2}}$$

$$= [\text{S}^{2-}] \left(1 + \frac{0.003205 \times 10^{22}}{1 + 3205} + \frac{0.15 \times 10^{14}}{15} \right)$$

$$C_{\text{Cu}^{2+}} = [\text{S}^{2-}] (1 + 3.2 \times 10^{19} + 1.5 \times 10^{12})$$

$$K_{\text{sp}} = [\text{S}^{2-}] (1 + 3.2 \times 10^{19} + 1.5 \times 10^{12})$$

$$[\text{S}^{2-}] = \frac{1 + 3.2 \times 10^{19} + 1.5 \times 10^{12}}{8 \times 10^{-37}}$$

اتحاد طلبة العلوم الحياتية 2012

غيرنا، صحتك

Quiz 1 Analytical Chemistry

Name.....

Reg. No.....

$$\frac{0.56 \times 10^{-1} \times 0.1}{0.56 \times 10^{-2}} = 0.748 \times 10^{-1} = 0.0748$$

$$pOH = -\log [OH^-] = -\log \left(\frac{K_b \times n_{NaOH}}{V_{tot}} \right) = -\log \left(\frac{1 \times 10^{-14} \times 0.1}{1.8 \times 10^{-5}} \right)$$

1. Calculate the pOH at the equivalence point for the titration of 0.10M acetic acid with 0.10 M NaOH given that K_a for acetic acid (CH_3COOH) = 1.8×10^{-5}

- a) 9.9 b) 7 c) 8.7 d) 5.3 e) 6.5

weak acid.

$$pH = \frac{pK_a + \log \left(\frac{[A^-]}{[HA]} \right)}{1} = \frac{4.74 + \log \left(\frac{0.56 \times 10^{-9} \times 0.1}{0.56 \times 10^{-5}} \right)}{1} = 7.4$$

2. 40.00 mL of 0.0900 M HCl is titrated with 0.1 M NaOH. Calculate the pOH after addition of 30.00 mL of NaOH

- a) 1.82 b) 2.34 c) 1.51 d) 2.07 e) 11.93

$$pH = \frac{n_{HCl} - n_{NaOH}}{V_{tot}} = \frac{3.6 - 3}{70} = 0.0085$$

$$pH_{30} = 8.6 \times 10^{-3}$$

$$pH = 11.93$$

3. In the titration of 40.00 mL of 0.110 M NH_3 ($K_b = 1.6 \times 10^{-5}$) with 0.100 M HCl. Calculate the pOH at the equivalence point.

- a) 6.38 b) 4.38 c) 5.24 d) 3.21 e) 8.76

weak base strong acid.

$$pH = \frac{pK_b + \log \left(\frac{[NH_4^+]}{[NH_3]} \right)}{1} = \frac{4.79 + \log \left(\frac{0.625 \times 10^{-9}}{1.6 \times 10^{-5}} \right)}{1} = 11.4$$

$$pOH = 14 - pH = 2.6$$

4. Which solution would provide the least sharp end point in the titration of 0.10 M HCl:

- a) 0.10 M NH_3 b) 0.10 M NaOH solution c) 0.01 M NaOH solution d) 0.01 M NH_3 solution e) 0.10 M acetic acid solution

$$pH = \frac{pK_a + \log \left(\frac{[A^-]}{[HA]} \right)}{1} = \frac{4.74 + \log \left(\frac{0.032 \times 10^{-1}}{32 \times 10^{-3} \times 10^{-6}} \right)}{1} = 5.66$$

5. Calculate the initial pH in the titration of 50.00 mL 0.05M HCl solution with 0.10 M NaOH:

- a) 1.3 b) 1.0 c) 7.0 d) 2.0 e) 13.0

$$pH = -\log [0.05] = 1.3$$

إنت السعادة تكمن في شدة الإيمان

ونشوة المحمود المبدع ...

اتحاد الطلبة ٢٠١٢

Quiz 1 (mid exam)

Analytical Chemistry

(سأيرة الحفنة والتمتع)

Principles of Neutralization Titration

Name.....

Reg. No..... 0101061

2
5

1. Calculate the pOH at the equivalence point for the titration of 0.10M acetic acid with 0.10 M NaOH given that K_a for acetic acid (CH_3COOH) = 1.8×10^{-5} .

- a) 9.9 b) 7 c) 8.7 ☒ d) 5.3 e) 6.5

2. 40.00 mL of 0.0900 M HCl is titrated with 0.1 M NaOH. Calculate the pOH after addition of 30.00 mL of NaOH

- a) 1.82 b) 2.34 c) 1.51 ☒ d) 2.07 ☒ e) 11.93

3. In the titration of 40.00 mL of 0.110 M NH_3 ($K_b = 1.6 \times 10^{-5}$) with 0.100 M HCl. Calculate the pOH after addition of 44.00 mL HCl.

- a) 6.38 b) 4.38 ☒ c) 5.24 d) 3.21 ☒ e) 8.76

4. Which solution would provide the least sharp end point in the titration of 0.10 M HCl:

- a) 0.10 M NH_3 ☒ b) 0.10 M NaOH solution c) 0.01 M NaOH solution
☒ d) 0.01 M NH_3 solution e) 0.10 M acetic acid solution

5. Calculate the initial pH in the titration of 50.00 mL 0.05M HCl solution with 0.10 M NaOH:

- ☒ a) 1.3 b) 1.0 c) 7.0 d) 2.0 e) 13.0

لا تحف من المسافة بين الكلم والحقيقة ...

فنادمت (ستطوحت أن تحلم بشيء .. فباركك حقيقة

بيلغا دافيز

Analytical Chemistry
First Exam

(Theory)

28
50

Name: Date:

Reg. No.: 0101167 Seat no.:

Section: 1 2 3 (4)

1. a b c d ~~X~~ 9. a b ~~X~~ d e
2. a ~~X~~ c d e 10. a ~~X~~ c d e
3. ~~X~~ b c d e 11. a b c d ~~X~~
4. ~~X~~ b ~~X~~ d e 12. a b c ~~X~~ e
5. a ~~X~~ c d ~~X~~ 13. ~~X~~ b c d e
6. ~~X~~ b c d e 14. a b c d ~~X~~
7. ~~X~~ b c d e 15. a b c ~~X~~ e
8. a ~~X~~ c d e

GOOD LUCK

$$M = \frac{d \times \% \times 10}{M_w} = \frac{1.149 \times 12.5 \times 10}{134}$$

1. A 12.5% (w/w) CuCl_2 (134.6 g mol^{-1}) solution has a density of 1.149 g mL^{-1} . Calculate the equilibrium concentration of Cl^- in this solution.

- a) 0.986M b) 0.0782M c) 0.870M d) 0.192M **e) 2.134M**

2. Brine water contains an average of 1.08×10^3 ppm of Na^+ (molar mass 23 g/mol), given that the density of the brine is 1.06 g/mL. Calculate the equilibrium molar concentration of Na^+ :

- a) 1.01 M **b) 0.0500 M** c) 0.0925 M d) 0.0759M e) 0.0369 M

3. Calculate the p-value of ClO_4^- in a solution that contains $3.35 \times 10^{-4} \text{ M}$ in $\text{Ba}(\text{ClO}_4)_2$ and $6.75 \times 10^{-4} \text{ M}$ in HClO_4 .

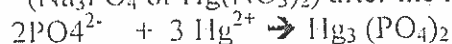
- a) 2.87** b) 6.70 c) 3.98 d) 4.60 e) 2.13

4. A solution was prepared by dissolving 7.56 g of $\text{KCl} \cdot \text{Mg}(\text{ClO}_4)_2 \cdot 6\text{H}_2\text{O}$ (molar mass = 277.85 g/mol) in sufficient water to give 3.00 L solution. Calculate the ppm of Mg^{2+} (molar mass = 24.3 g/mol)

- a) 220.4 b) 304.1 c) 20.9 d) 150.1 e) 73.5

$$7.56 \times 10^{-3} = \frac{\text{moles}}{3}$$

5. When a 30.0 mL of 0.3757 M solution of Na_3PO_4 were mixed with 100.0 mL of 0.5151 M $\text{Hg}(\text{NO}_3)_2$, calculate the molarity of the unreacted species (Na_3PO_4 or $\text{Hg}(\text{NO}_3)_2$) after the reaction was complete:



- a) 0.0917M b) 0.2663 M c) 0.118 M
d) $3.20 \times 10^{-2} \text{ M}$ e) $8.23 \times 10^{-5} \text{ M}$

6. The correct statement among the following is:

- a) Constant errors have the same 'absolute' magnitude regardless of sample size.**
b) All analytical measurements have determinate errors.
c) Random errors are evaluated by the closeness of measured values to the true value.
d) Determinate errors are mathematically expressed by the CV (%).
e) Proportional errors have the same absolute magnitude regardless of the sample size

7. Suppose that 0.1 mg of a precipitate was lost as a result of being washed with 300 mL of wash liquid. If the precipitate weighed 500mg, encircle the correct statement:

- a) The relative error due to solubility loss is -0.02%.
 b) The relative error due to solubility is +2.0%
 c) An increase in replicate measurements should increase accuracy
 d) An increase in replicate measurements should decrease precision.
 e) None of the statements above is correct.

8. The result of the calculation $[\log 7.230 \times 10^9]$ is reported as

9.8591

- a) 9.86 b) 9.8591 c) 9.859 d) 9.85910 e) 9.859100

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}}$$

$$217.2675, 1067.67, 1052.9, 1000.9 \} = \frac{11214}{3} = \sqrt{3738} = 61.14$$

9. A chemist obtained the following data for percent endosulfan in a triplicate analysis of an insecticide preparation: 6.98, 7.47, and 7.27 %. Calculate the 95% confidence limits for the mean of the three data points, assuming that no further information is given about the precision of the method.

$$\bar{x} = \frac{7.24 + 7.24 + 7.24}{3} = 7.24$$

$$a = \bar{x} \pm \frac{t_{0.05, 2} s}{\sqrt{n}} = 7.24 \pm \frac{2.01 \times 0.41}{\sqrt{3}}$$

- a) 7.24 ± 0.41 b) 7.24 ± 0.54 c) 7.24 ± 0.61 d) 7.24 ± 0.83 e) 7.24 ± 0.73

$$\frac{0.8643}{1.414} = 0.61$$

10. How many replicate measurements are needed to decrease the 95% confidence intervals for the analysis of iron with the confidence interval of $18.5 \pm 3.3 \mu\text{g Fe/ml}$ to $\pm 1.5 \mu\text{g Fe/ml}$. Given that the population standard deviation for the method $\sigma = 2.1$.

$$\sqrt{n} \cdot 1.5 = 2.1 \times 1.96$$

- a) 6 b) 10 c) 8 d) 9 e) 7

11. The following results were obtained for the determination of Phosphorous in blood serum: 4.40, 4.42, 4.60, 4.48, and 4.50 ppm. Which of the data points should be rejected at 95% confidence.

$$4.40, 4.42, 4.60, 4.48, 4.50 \} \rightarrow 4.60 \text{ is rejected}$$

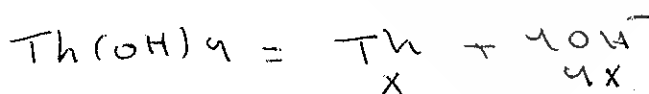
- a) 4.60 b) 4.40 c) 4.50 d) 4.48 e) all values must be retained

$$\frac{1}{2} \times 4.60 = 2.30$$

710

12. Calculate the thermodynamic solubility product constant for $\text{Th}(\text{OH})_4$, where the molar solubility of its saturated solution is $3.3 \times 10^{-4} \text{ M}$

- a) 3.89×10^{-18} b) 6.88×10^{-17} c) 1.18×10^{-14} d) 1.00×10^{-15} e) 1.18×10^{-16}



$$K_{sp} = [\text{Th}^{4+}] [\text{OH}^-]^4$$

256

$$K_b = 7.352 \times 10^{-12}$$

$$[OH^-] = \sqrt{7.352 \times 10^{-12} \times 1} = 8.57 \times 10^{-7}$$

13. What is the hydronium ion concentration in 0.100 M sodium chlorate (ClO_3Na) given that $K_a = 1.36 \times 10^{-3}$

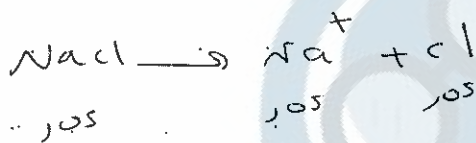
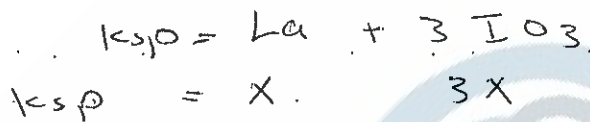
- a) 1.17×10^{-8} M b) 4.30×10^{-7} M c) 5.15×10^{-6} M d) 8.57×10^{-7} M e) 3.51×10^{-8} M

14. What weight of sodium formate (molar mass 68.0g/mol) must be added to 400.00 ml of 1.00 M formic acid to produce a buffer solution that has a pH of 3.5. (Given that K_a for formic acid = 1.8×10^{-4})

- a) 10.5 g b) 196.9 g c) 38.7 g d) 27.2 g e) 15.5 g

15. Use activities to calculate the molar solubility of $La(IO_3)_3$ in 0.05M NaCl. Given that $K_{sp} La(IO_3)_3 = 1.1 \times 10^{-11}$

- a) 1.6×10^{-2} b) 1.5×10^{-1} M c) 7.4×10^{-5} d) 1.3×10^{-3} e) 7.6×10^{-4}



$$La = 8 = ,24$$

$$IO_3 = 8 = ,81$$

$$K_{sp} = 8[x] \cdot 8^3 [3x]^3$$

$$1.1 \times 10^{-11} = ,24x \cdot (81)^3 (3x^3)$$

End

$$1,1 \times 10^{-11} = 27 \times 81^3 x^4$$

$$1,1 \times 10^{-11} = 27 \times 5314 x^4$$

$$1,1 \times 10^{-11} = 143484 x^4$$

$$x^4 = \frac{1,1 \times 10^{-11}}{143484} = 7.66 \times 10^{-17}$$

$$x = \sqrt[4]{7.66 \times 10^{-17}} = 1.75 \times 10^{-3}$$

$$pH = pK_a + \log \frac{[A^-]}{[HA]}$$

$$3.5 = 3.74 + \log \frac{[A^-]}{1}$$

$$-,24 = \log [A^-]$$

$$,58 = [A^-]$$

$$,58 = \frac{\text{moles}}{400}$$

Activity Coefficients for Ions at 25 °C

Ion	α , nm	Activity Coefficient at Indicated Ionic Strength				
		0.001	0.005	0.01	0.05	0.1
H ₃ O ⁺	0.9	0.967	0.934	0.913	0.85	0.81
Li ⁺ , C ₆ H ₅ COO ⁻	0.6	0.966	0.930	0.907	0.83	0.80
Na ⁺ , IO ₃ ⁻ , HSO ₄ ⁻ , HCO ₃ ⁻ , H ₂ PO ₄ ⁻ , H ₂ AsO ₄ ⁻ , OAc ⁻	0.4-0.45	0.965	0.927	0.902	0.82	0.77
OH ⁻ , F ⁻ , SCN ⁻ , HS ⁻ , ClO ₄ ⁻ , ClO ₃ ⁻ , BrO ₃ ⁻ , IO ₄ ⁻ , MnO ₄ ⁻	0.35	0.965	0.926	0.900	0.81	0.76
K ⁺ , Cl ⁻ , Br ⁻ , I ⁻ , CN ⁻ , NO ₂ ⁻ , NO ₃ ⁻ , HCOO ⁻	0.3	0.965	0.925	0.899	0.81	0.75
Rb ⁺ , Cs ⁺ , Tl ⁺ , Ag ⁺ , NH ₄ ⁺	0.25	0.965	0.925	0.897	0.80	0.75
Mg ²⁺ , Be ²⁺	0.8	0.872	0.756	0.690	0.52	0.44
Ca ²⁺ , Cu ²⁺ , Zn ²⁺ , Sn ²⁺ , Mn ²⁺ , Fe ²⁺ , Ni ²⁺ , Co ²⁺ , Phthalate ²⁻	0.6	0.870	0.743	0.676	0.48	0.40
Sr ²⁺ , Ba ²⁺ , Cd ²⁺ , Hg ²⁺ , S ²⁻	0.5	0.869	0.713	0.668	0.46	0.38
Pb ²⁺ , CO ₃ ²⁻ , SO ₄ ²⁻ , C ₂ O ₄ ²⁻	0.45	0.868	0.711	0.665	0.45	0.36
Hg ₂ ²⁺ , SO ₃ ²⁻ , S ₂ O ₃ ²⁻ , Cr ₂ ⁴⁺ , HPO ₄ ²⁻	0.40	0.867	0.738	0.661	0.44	0.35
Al ³⁺ , Fe ³⁺ , Cr ³⁺ , La ³⁺ , Ce ³⁺	0.9	0.737	0.510	0.443	0.24	0.18
PO ₄ ³⁻ , Fe(CN) ₆ ⁴⁻	0.4	0.726	0.505	0.391	0.16	0.095
Th ⁴⁺ , Zr ⁴⁺ , Ce ⁴⁺ , Sn ⁴⁺	1.1	0.587	0.343	0.252	0.10	0.063
Fe(CN) ₆ ³⁻	0.5	0.569	0.305	0.200	0.017	0.020

Confidence Levels for Various Values of z

Confidence Level, %	z
50	0.67
68	1.00
80	1.28
90	1.64
95	1.96
95.4	2.00
99	2.58
99.7	3.00
99.9	3.29

Values of t for Various Levels of Probability

Degrees of Freedom	80%	90%	95%	99%	99.9%
1	3.08	6.31	12.7	63.7	637
2	1.89	2.92	4.30	9.92	31.6
3	1.64	2.35	3.18	5.84	12.9
4	1.53	2.13	2.78	4.60	8.61
5	1.48	2.02	2.57	4.03	6.87
6	1.44	1.94	2.45	3.71	5.96
7	1.42	1.90	2.36	3.50	5.41
8	1.40	1.86	2.31	3.36	5.04
9	1.38	1.83	2.26	3.25	4.78
10	1.37	1.81	2.23	3.17	4.59
15	1.34	1.75	2.13	2.95	4.07
20	1.32	1.73	2.09	2.84	3.85
40	1.30	1.68	2.02	2.70	3.55
60	1.30	1.67	2.00	2.62	3.46
∞	1.28	1.64	1.96	2.58	3.29

Critical Values for the Rejection Quotient, Q*

Number of Observations	Q _{crit} (Reject if Q > Q _{crit})		
	90% Confidence	95% Confidence	99% Confidence
3	0.941	0.970	0.994
4	0.765	0.829	0.926
5	0.642	0.710	0.821
6	0.560	0.625	0.740
7	0.507	0.568	0.680
8	0.468	0.526	0.634
9	0.437	0.493	0.598
10	0.412	0.466	0.568

B.S.S. - قسم الكيمياء التحليلية
19/11/09
تحليل آلي
Analytical Chemistry
First Exam

17.4
30

Date: 25/3/2009

Time: 1 hour

Name: [REDACTED] Registration Number: 0075639

Section: lecture days Sun, Tues, Wed lecture time 8-9

Lecturer: ALAWI

TUTUNJI ✓

1. ☒ A ☐ B ☒ C ☐ D ☐ E
2. ☐ A ☐ B ☐ C ☐ D ☒ E
3. ☐ A ☐ B ☐ C ☒ D ☒ E
4. ☐ A ☐ B ☐ C ☐ D ☒ E
5. ☐ A ☒ B ☐ C ☐ D ☐ E
6. ☐ A ☐ B ☐ C ☐ D ☒ E
7. ☒ A ☐ B ☐ C ☐ D ☐ E
8. ☐ A ☒ B ☒ C ☐ D ☐ E
9. ☐ A ☐ B ☐ C ☒ D ☒ E
10. ☐ A ☒ B ☐ C ☐ D ☐ E
11. ☐ A ☒ B ☐ C ☒ D ☐ E
12. ☐ A ☐ B ☒ C ☐ D ☒ E
13. ☒ A ☐ B ☐ C ☐ D ☐ E
14. ☐ A ☒ B ☒ C ☐ D ☐ E
15. ☐ A ☒ B ☐ C ☐ D ☒ E
16. ☐ A ☐ B ☒ C ☐ D ☐ E
17. ☒ A ☐ B ☐ C ☐ D ☐ E
18. ☐ A ☐ B ☒ C ☐ D ☐ E
19. ☐ A ☒ B ☒ C ☐ D ☐ E
20. ☐ A ☐ B ☐ C ☒ D ☒ E

GOOD LUCK

Questions 1-4

A solution was prepared by dissolving **605 mg** of $\text{K}_3\text{Fe}(\text{CN})_6$ (329.2 g mol^{-1}) in sufficient water to give a final volume **775 ml**. Answer questions **1 to 4**. (AW) for K = 39.1 g/mol

Q1 Calculate the analytical molar concentration of $\text{K}_3\text{Fe}(\text{CN})_6$.

- (A) $2.37 \times 10^{-3} \text{ M}$ (B) $9.84 \times 10^{-2} \text{ M}$ (C) $1.28 \times 10^{-1} \text{ M}$
(D) $3.12 \times 10^{-5} \text{ M}$ (E) $5.02 \times 10^{-4} \text{ M}$

Q2 Calculate the equilibrium molar concentration of K^+ .

- (A) $3.89 \times 10^{-3} \text{ M}$ (B) $5.63 \times 10^{-3} \text{ M}$ (C) $9.83 \times 10^{-2} \text{ M}$
(D) $8.98 \times 10^{-3} \text{ M}$ (E) $7.11 \times 10^{-3} \text{ M}$

Q3 Calculate the number of millimoles of K^+ in 100.0 ml of the above solution.

- (A) 0.105 mmol (B) 0.237 mmol (C) 327 mmol
(D) 0.711 mmol (E) 0.711 mmol

Q4 How many ppm of $\text{Fe}(\text{CN})_6^{3-}$ ($211.58 \text{ g mol}^{-1}$) are there in the above solution.

- (A) 955.34 (B) 305.12 (C) 211.58
(D) 1050.12 (E) 502.2

Questions 5-7

A **5.89 % (w/w)** $\text{Fe}(\text{NO}_3)_3$ ($241.86 \text{ g mol}^{-1}$) solution has a density of **1.059 g ml⁻¹**. Answer questions **5 to 7**.

Q5 The analytical molar concentration of $\text{Fe}(\text{NO}_3)_3$ is:

- (A) 0.303 M (B) 0.258 M (C) 0.774
(D) 1.203 (E) 0.0940

Q6 The PNO_3^- is

- (A) 3.18 (B) 0.981
(D) 2.38 (E) 0.111

Q7 Calculate the volume (ml) of $\text{Fe}(\text{NO}_3)_3$ solution to prepare a 500.0ml that is $0.9682 \times 10^{-2} \text{M}$ in NO_3^- .

- (A) 6.254 ml (B) 3.125 ml (C) 78.5ml
(D) 63.1ml (E) 77.38ml

Q8 What mass of solid PbCl_2 (278.0 g mol^{-1}) is formed when 150ml of 0.125M Pb^{2+} are mixed with 400ml of 0.175M Cl^- .

- (A) 4.86g (B) 9.73g (C) 5.213g
(D) 2.61g (E) 1.68g

Questions 9 - 11

A hydrochloric acid solution was standardized by titration with TRIS. The results of the titrations gave concentrations of **0.1522 M**, **0.1526 M**, **0.1614 M**, and **0.1607 M**.

Q9 Can any of the points be rejected at the 95% confidence interval? If so, which one(s)?

- (A) 0.1522M (B) 0.1526M (C) 0.1614M
(D) 0.1607M (E) None of the above

Q10 For all the points above, calculate the relative standard deviation in ppt.

- (A) 62.64 (B) 31.91 (C) 71.31
(D) 0.157 (E) 2.205×10^{-3}

Q11 For all the points above calculate the confidence interval for μ at the 95% confidence level.

(A) 0.157 ± 6.52

(B) 0.0156

(C) 3.25×10^{-3}

(D) $0.157 \pm 6.95 \times 10^{-3}$

(E) $0.157 \pm 6.86 \times 10^{-4}$

Q12 What is the density of 54.3 wt % aqueous NaOH (MW = 40.00) if 17.6 ml of the solution diluted to 2.00 L gives 0.196 M NaOH?

(A) 1.64 g/ml

(B) 3.92 g/ml

(C) 1.32 g/ml

(D) 2.88 g/ml

(E) 0.62 g/ml

Q13 Calculate the pH of a 0.0090 M solution of the weak acid HA, with a $K_a = 1.00 \times 10^{-4}$.

(A) 3.02

(B) 10.98

(C) 6.04

(D) 1.32

(E) 4.68

Q14 Calculate the pH of 0.0850 M pyridinium bromide, $\text{C}_5\text{H}_5\text{NH}^+\text{Br}^-$, with a $K_a = 7.05 \times 10^{-4}$.

(A) 8.04

(B) 5.62

(C) 3.15

(D) 4.68

(E) 10.85

Q15 A 0.100 M solution of the weak acid HA has a pH of 2.36. Calculate pK_a for HA .

(A) 2.1

(B) 3.7

(C) 1.3

(D) 4.6

(E) 5.8

Q16 Calculate the pH of a 0.05M solution of the weak base with $K_b = 1.00 \times 10^{-4}$.

- (A) 10.21 (B) 7.69
(D) 9.68 (E) 8.52

(C) 11.35

Q17 Calculate the solubility product constant of $Pb(IO_3)_2$ given that the molar concentration of its saturated solution is $1.42 \times 10^{-4} M$.

- (A) 1.3×10^{-9} (B) 5.6×10^{-14} (C) 2.86×10^{-12}
(D) 2.3×10^{-11} (E) 3.2×10^{-13}

Q18 Encircle the wrong statement:

- (A) Water is an amphiprotic solvent
(B) $OC\bar{I}$ is the conjugate base of $HOCl$
(C) The conjugate acid of a Bronsted-Lowry base is the species formed when an acid accepts a proton
(D) Autoprotolysis of a solvent produces both a conjugate acid and a conjugate base
(E) Solutions of a salt like NH_4Cl are acidic

For questions 19 to 20 calculate the answer and the appropriate uncertainty for each of the following results:

Q19 $15.8 (\pm 0.6) + 7.3 (\pm 0.3) - 23.1 (\pm 0.4) =$

- (A) $1.3 (\pm 0.1)$ (B) $2.1 (\pm 0.2)$ (C) $0.0 (\pm 0.8)$
(D) $0.01 (\pm 0.05)$ (E) $0.0 (\pm 0.5)$

Q20 $\frac{44.4 (\pm 0.5)}{3.18 (\pm 0.02) \times 10^4} =$

- (A) $1.44 (\pm 0.3) \times 10^{-2}$ (B) $44.4 (\pm 0.5) \times 10^3$ (C) $1.40 (\pm 0.1) \times 10^4$
(D) $1.40 (\pm 0.02) \times 10^{-3}$ (E) $4.44 (\pm 0.02) \times 10^3$

CRITICAL VALUES FOR REJECTION QUOTIENT Q			
Number of Observations			
	90% Confidence	95% Confidence	99% Confidence
3	0.94	0.98	0.99
4	0.76	0.85	0.93
5	0.64	0.73	0.82
6	0.56	0.64	0.74
7	0.51	0.59	0.68
8	0.47	0.54	0.63

CONFIDENCE LEVELS FOR VARIOUS VALUES OF Z	
CONFIDENCE LEVEL, %	Z
50	0.67
68	1.00
80	1.29
90	1.64
95	1.96
96	2.00
99	2.58
99.7	3.00

Values of t for Various Levels of Probability				
Degree of Freedom	Factor for Confidence Interval			
	80%	90%	95%	99%
1	3.08	6.31	12.7	63.7
2	1.89	2.92	4.30	9.92
3	1.64	2.35	3.18	5.84
4	1.53	2.13	2.78	4.60
5	1.48	2.02	2.57	4.03
6	1.44	1.94	2.45	3.71

كامل الحياتية
Analytical Chemistry
Second Exam

Second Semester 2008/2009

Time 1 hour 15 minutes

Date: 10/5/2009

Name: [redacted] Registration Number: 0075639

Section: lecture days: lecture time: (A-4)

Lecturer: ALAWI TUTUNJI

1. ☒ A B C D E

10. ☒ A B C D E

2. ☒ A ☒ B C D E

11. A B ☒ C D E

3. ☒ A B C D ☒ E

12. A B C D ☒ E

4. A B C ☒ D E

13. ☒ A B ☒ C D E

5. A ☒ B ☒ C D E

14. A B ☒ C D E

6. ☒ A ☒ B C D E

15. A B ☒ C D E

7. A ☒ B ☒ C ☒ D E

16. A B ☒ C D E

8. ☒ A B C D ☒ E

17. A ☒ B C D E

9. A B C D ☒ E

18. A B C D ☒ E

Good Luck

1

اتحاد طلبة العلوم الحياتية 2012

عبدالله حسن

$$\frac{[CH_3NH_2]}{[CH_3NH_3^+]} \quad pH = pK_a + \log \frac{[CH_3NH_2]}{[CH_3NH_3^+]} \quad 1 = -3.59$$

Q1 Calculate the ratio $[CH_3NH_2]/[CH_3NH_3^+]$ in a methylamine solution that has been buffered to $pH = 4.00$ given that $K_a = 2.29 \times 10^{-11}$

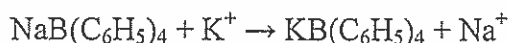
- (a) 2.3×10^{-7} (b) 1.00 (c) 23.12

- (d) 8.5×10^{-5} (e) None of the above

$$pH = \log K_a + \log \frac{[CH_3NH_2]}{[CH_3NH_3^+]}$$

$$pH = pK_a + \log \frac{[A^-]}{[HA]} \quad [A^-] = -\log K_a - \log \frac{[HA]}{[A^-]}$$

Q2 A 2.4414g sample containing KCl, K_2SO_4 and inert material was dissolved in sufficient water to give 250ml of solution. A Mohr titration of a 50.00 ml aliquot required 41.36 ml of 0.0443M $AgNO_3$. A second 50.0ml aliquot was treated with 40.00 ml of 0.1083M $NaB(C_6H_5)_4$. The reaction is:



The solid was filtered, redissolved in acetone, and titrated with 49.98ml of $AgNO_3$ solution. Calculate the percentage of KCl and K_2SO_4 in the sample.

- (a) % KCl 36.73, % K_2SO_4 8.95 (b) % KCl 45.24, % K_2SO_4 13.29
(c) % KCl 15.24, % K_2SO_4 42.81 (d) % KCl 30.62, % K_2SO_4 41.26
(e) % KCl 41.62, % K_2SO_4 17.28

Questions 3 to 6

Calculate the silver ion concentration after the addition of the following volumes (ml) of 0.0500M $AgNO_3$ to 50.0ml of 0.0400 M KBr given that the K_{sp} for $AgBr = 5.0 \times 10^{-13}$.

Q3 Calculate the $[Ag^+]$ at zero volume of $AgNO_3$ added.

- (a) $[Ag^+] = 0.0500M$ (b) $2 \times 10^{-5}M$ (c) 5.00×10^{-13} (d) 0.0400M

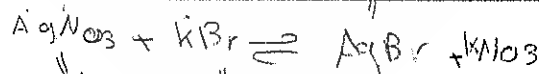
- (e) $pAg^+ = \infty$

$$AgNO_3 = [0.05] \quad KBr \quad V = 50.0 mL, [0.04]$$

$$K_{sp} = 5.0 \times 10^{-13}$$

$$[Ag^+] =$$

2



$$\downarrow \quad \downarrow \quad \downarrow \quad \downarrow$$

$$0.05 \quad 0.04 \quad 7 \times 10^{-3} \quad 0.05$$

0.5 M AgNO₃

Q4 Calculate the pAg⁺ after the addition of 5.00ml of the silver ion.

(a) $1.6 \times 10^{-11} \text{ M}$

(b) 3.51

(c) 8.96

(d) 10.80

(e) 12.80

$$[Ag^+] = \frac{K_{sp} \cdot V_{tot}}{n_{X^-} - n_{Ag}} = \frac{1.6 \times 10^{-13} \times (0.05 + 0.05)}{2 \times 10^{-3} - 2.5 \times 10^{-4}} = \frac{2.75 \times 10^{-4}}{1.75 \times 10^{-3}} = 1.57 \times 10^{-4}$$

Q5 Calculate the silver ion concentration after the addition of 40.00ml of AgNO₃.

(a) $3.5 \times 10^{-3} \text{ M}$

(b) 7.1×10^{-7}

(c) pAg⁺ = 9.8

(d) $1.6 \times 10^{-5} \text{ M}$

(e) $1.6 \times 10^{-2} \text{ M}$

$$= \frac{K_{sp} \cdot V_{tot}}{n_{X^-} - n_{Ag}} = \frac{1.6 \times 10^{-13} \times 0.05}{2 \times 10^{-3} - 2.5 \times 10^{-4}} = 1.57 \times 10^{-4}$$

$$= \frac{1.6 \times 10^{-13} \times (0.04 + 0.05)}{2 \times 10^{-3} - 2 \times 10^{-3}} = \frac{1.6 \times 10^{-13} \times 0.09}{0} = \text{undefined}$$

Q6 Calculate the pAg⁺ after the addition of 50.00ml of AgNO₃.

(a) 2.30

(b) 6.15

(c) 9.86

(d) 5.46

(e) 4.39

Q7 The digestion of a 0.1432g sample of a compound containing phosphorous in a mixture of HNO₃ and H₂SO₄ resulted in the formation of CO₂, H₂O, and H₃PO₄. Addition of ammonium molybdate yielded a solid having a composition (NH₄)₃PO₄·12MoO₃ (MW = 1876.3 g/mol). This precipitate was filtered, washed, and dissolved in 50.00ml of 0.2000 M NaOH:



The solution was then boiled to remove the NH₃, the excess NaOH was titrated with 14.71 ml of 0.1741 M HCl to a phenolphthalein end point. Calculate the percentage of phosphorous in the sample.

(a) 62.86%

(b) 6.19%

(c) 26.68%

(d) 9.16%

(e) 6.91%

$$\% = \frac{\text{mass of P}}{\text{mass of sample}} \times 100 = \frac{0.1432 \text{ g}}{0.1432 \text{ g}} \times 100 = 100\%$$

NaOH

26 mol

$$2.56 \times 10^{-3}$$

NaOH

$$2.56 \times 10^{-3}$$

HPO₄

$$1 \text{ mol}$$

3

$$\Rightarrow \text{mol} = 9.85 \times 10^{-5}$$

$$\Rightarrow 2.56 \times 10^{-3}$$

$$2.56 \times 10^{-3}$$

$$\Rightarrow HPO_4 = 10.15 \times 10^{-3} \text{ mol}$$

HPO₄

1 mol

P

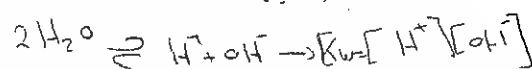
1 mol

$$\Rightarrow \text{mol} = 10.15 \times 10^{-3}$$

Q8 Encircle the correct statement:

- (a) For colloidal precipitates, analysts should initially dilute the test solution to cause coagulation
- (b) Analysts should perform a digestion step during precipitation to decrease the size of the 1^o and 2^o adsorption layers, ($\frac{5}{3}$)
- (c) Digestion and peptization are important to obtain cleaner precipitates $\times$
- (d) Crystalline precipitates can never be contaminated by surface adsorption $\checkmark$
- (e) Mixed crystal formation may be reduced by digestion $FeCO_3 \rightleftharpoons Fe^{+2} + CO_3^{-2}$

$$K_{sp} = [Fe^{+2}][CO_3^{-2}]$$



Questions 9-13

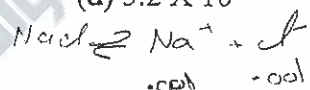
Consider the dissociation of iron (II) carbonate ($FeCO_3$; $K_{sp} = 2.1 \times 10^{-11}$) $CO_3^{-2} + H_2O \rightleftharpoons$



Q9 Calculate the molar solubility of $FeCO_3$ in water (Hint - assume $\gamma_i = 1$ for all ions in this situation).

- (a) 8×10^{-5} (b) 7.1×10^{-4} (c) 1.1×10^{-2} (d) 5.2×10^{-8}
- (e) 4.6×10^{-6}

$$K_{sp} = [Fe^{+2}][CO_3^{-2}]$$



$$= [(0.001) \times 1 + (0.001) \times 1] \times \frac{1}{2}$$

Q10 Calculate the concentration solubility product constant for $FeCO_3$ in 0.0010 M NaCl.

- (a) 2.8×10^{-11} (b) 3.2×10^{-9} (c) 5.1×10^{-7} (d) 5.2×10^{-8}
- (e) 6.5×10^{-4}

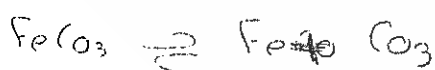
$$K_{sp} = [Fe^{+2}][CO_3^{-2}]$$

$$\frac{2.1 \times 10^{-11}}{0.87 \times 0.868} = [x]^2$$

Q11 Calculate the molar solubility of $FeCO_3$ in 0.0010M NaCl.

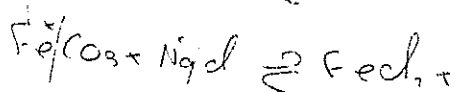
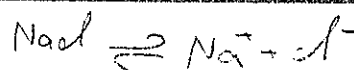
- (a) 1.3×10^{-4} M (b) 3.2×10^{-9} M (c) 5.3×10^{-6} M
- (d) 9.5×10^{-9} M (e) 4.5×10^{-7} M

4



$$K_{sp} = [x][x]$$

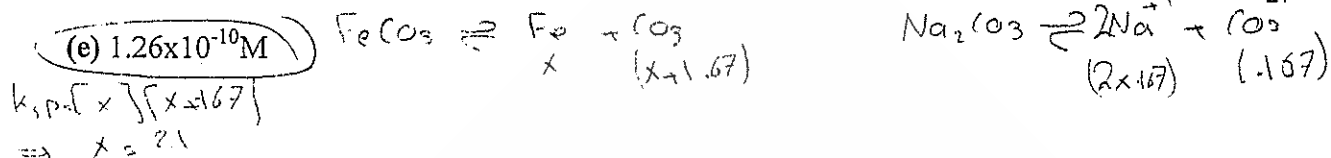
$$2.1 \times 10^{-11}$$



$$K_{sp} = 2.1 \times 10^{-11}$$

Q12 Calculate the molar solubility of FeCO_3 in a solution of 0.167 M Na_2CO_3 .

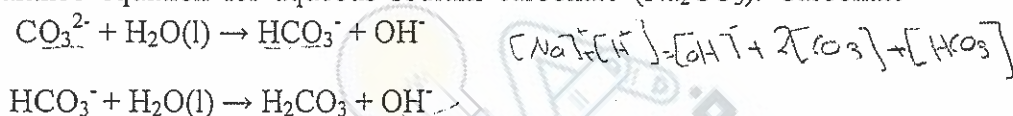
- (a) $4.8 \times 10^{-6} \text{M}$ (b) $2.3 \times 10^{-8} \text{M}$ (c) $5.3 \times 10^{-6} \text{M}$ (d) $3.9 \times 10^{-5} \text{M}$



Q13 Calculate the percent relative error associated with the assumption that the activity would equal the concentration for question 11.

- (a) -10% (b) +5% (c) -13.2% (d) -8.2% (e) 3.6%

Q14 Write the charge balance equation for aqueous sodium carbonate (Na_2CO_3). Carbonate reacts as follows:



- (a) $[\text{Na}^+] = [\text{OH}^-] + [\text{HCO}_3^-] + 2[\text{CO}_3^{2-}]$
- (b) $[\text{Na}^+] = [\text{H}_2\text{CO}_3] + [\text{HCO}_3^-] + [\text{CO}_3^{2-}]$
- (c) $[\text{H}^+] + [\text{Na}^+] = [\text{OH}^-] + [\text{HCO}_3^-] + 2[\text{CO}_3^{2-}]$
- (d) $2[\text{CO}_3^{2-}] + [\text{OH}^-] = [\text{Na}^+] + [\text{H}_3\text{O}^+]$
- (e) None of the above

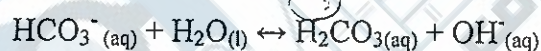
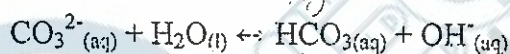
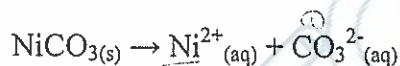
Q15 As ionic strength increases, the values of the activity coefficients:

- (a) Change randomly (b) increase (c) decrease (d) do not change
- (e) None of the above

Q16 Encircle the correct statement(s):

- ✓(a) Inclusion of mixed-crystal formation is a type of co-precipitation in which contaminant ion is trapped in the crystalline space.
- (b) A 2° adsorption layer describes a layer of solution surrounding a charged particle that contains excess of charged ions.
- ✓(c) Peptization is a process by which a coagulated colloid returns to its original dispersed state as a consequence of decreased electrolyte concentration.
- (d) Peptization can be avoided by washing the coagulated colloid with a large volume of water
- (e) Digestion is a process in which a precipitate is cooled in the presence of the solution from which it was formed

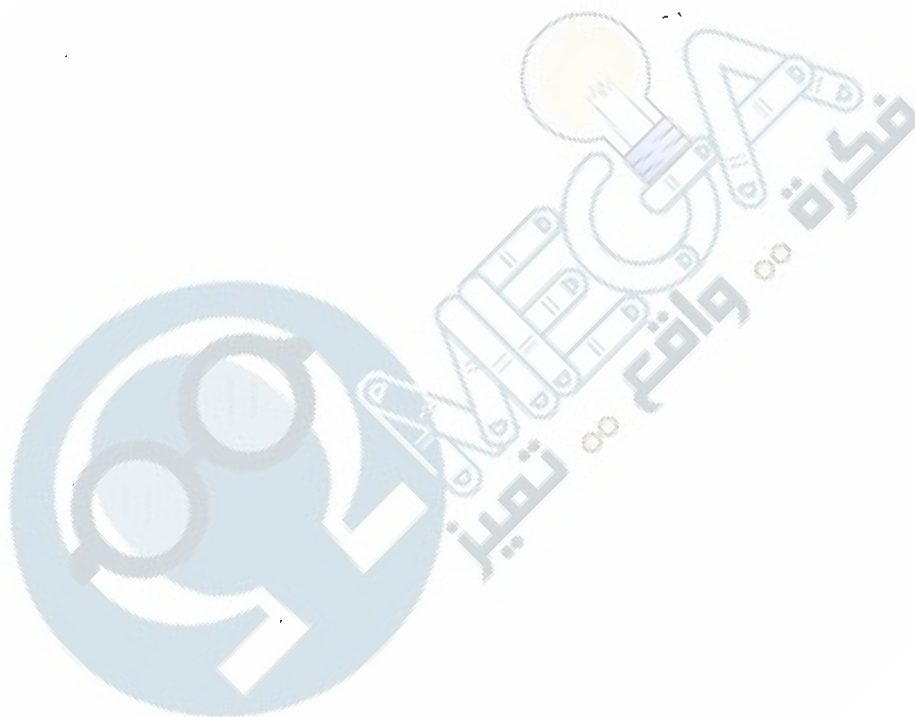
Q17 What is the mass balance for the following chemical equations?



- (a) $[\text{Ni}^{2+}]^2 + [\text{H}^+] = [\text{CO}_3^{2-}]^2 + [\text{HCO}_3^-] + [\text{OH}^-]$
- ✓(b) $[\text{Ni}^{2+}] = [\text{CO}_3^{2-}] + [\text{HCO}_3^-] + [\text{H}_2\text{CO}_3]$
- (c) $2[\text{Ni}^{2+}] = 2[\text{H}^+] + 2[\text{CO}_3^{2-}] + [\text{HCO}_3^-] + [\text{H}_2\text{CO}_3] + [\text{OH}^-]$
- (e) $2[\text{Ni}^{2+}] = 2[\text{CO}_3^{2-}] + [\text{HCO}_3^-] + [\text{H}_2\text{CO}_3]$

Q18 Encircle the correct statement

- (a) Gravimetric analysis is more accurate than volumetric analysis because the analytical signal is mass of a precipitate
- (b) The primary standard is necessary to standardize another primary standard
- (c) In volumetric analysis the interferences are similar to those of gravimetric analysis
- (d) One can choose a common indicator for all volumetric titrations
- (e) Equivalence points always occur before endpoints in volumetric analysis



University of Jordan
Department of Chemistry
Analytical Chemistry 211
May 10, 09

Time: 75 min

Student's Name: _____

Activity Coefficients for Ions at 25 °C

Ion	Activity Coefficient at Indicated Ionic Strength					
	α , nm	0.001	0.005	0.01	0.05	0.1
H_3O^+	0.9	0.967	0.934	0.913	0.85	0.83
$\text{Li}^+, \text{C}_6\text{H}_5\text{COO}^-$	0.6	0.966	0.930	0.907	0.83	0.80
$\text{Na}^+, \text{IO}_3^-, \text{HSO}_3^-, \text{H}_2\text{PO}_4^-, \text{H}_2\text{AsO}_4^-, \text{OAc}^-$	0.4-0.45	0.965	0.927	0.902	0.82	0.77
$\text{OH}^-, \text{F}^-, \text{SCN}^-, \text{HS}^-, \text{ClO}_3^-, \text{ClO}_4^-, \text{BrO}_3^-, \text{IO}_4^-, \text{MnO}_4^-$	0.35	0.965	0.926	0.900	0.81	0.75
$\text{K}^+, \text{Cl}^-, \text{Br}^-, \text{I}^-, \text{CN}^-, \text{NO}_2^-, \text{NO}_3^-, \text{HCOO}^-$	0.3	0.965	0.925	0.899	0.81	0.75
$\text{Rb}^+, \text{Cs}^+, \text{Tl}^+, \text{Ag}^+, \text{NH}_4^+$	0.25	0.965	0.925	0.897	0.80	0.75
$\text{Mg}^{2+}, \text{Be}^{2+}$	0.8	0.872	0.756	0.690	0.52	0.44
$\text{Ca}^{2+}, \text{Cu}^{2+}, \text{Zn}^{2+}, \text{Sn}^{2+}, \text{Mn}^{2+}, \text{Fe}^{2+}, \text{Ni}^{2+}, \text{Co}^{2+}, \text{Phthalate}^{2-}$	0.6	0.870	0.748	0.676	0.48	0.40
$\text{Sr}^{2+}, \text{Ba}^{2+}, \text{Cd}^{2+}, \text{Hg}^{2+}, \text{S}^{2-}$	0.5	0.869	0.743	0.668	0.46	0.38
$\text{Pb}^{2+}, \text{CO}_3^{2-}, \text{SO}_3^{2-}, \text{C}_2\text{O}_4^{2-}$	0.45	0.868	0.741	0.665	0.45	0.36
$\text{Hg}_2^{2+}, \text{SO}_4^{2-}, \text{S}_2\text{O}_3^{2-}, \text{CrO}_4^{2-}, \text{HPO}_4^{2-}$	0.40	0.867	0.738	0.661	0.44	0.35
$\text{Al}^{3+}, \text{Fe}^{3+}, \text{Cr}^{3+}, \text{La}^{3+}, \text{Ce}^{3+}$	0.9	0.737	0.540	0.443	0.24	0.18
$\text{PO}_4^{3-}, \text{Fe}(\text{CN})_6^{3-}$	0.4	0.726	0.505	0.394	0.16	0.095
$\text{Th}^{4+}, \text{Zr}^{4+}, \text{Ce}^{4+}, \text{Sn}^{4+}$	1.1	0.587	0.348	0.252	0.10	0.063
$\text{Fe}(\text{CN})_6^{4-}$	0.5	0.596	0.305	0.200	0.047	0.020

Source: J. Kielland, J. Am. Chem. Soc., 1937, 59, 1675. Courtesy of the American Chemical Society.

$$\text{Fe}^{+2} = .870$$

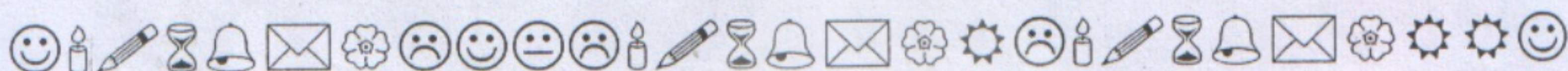
$$\text{CO}_3^{-2} = .868$$

* LANTHANIDE SERIES

90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	(No)	Lr
				(244)	(243)	(245)	(247)	(249)	(249)	(255)	(255)	(254)	(257)

Date: 13/11/2010
Time: 75 minutes

Section: 2:00 - 3:00 202



1.	a	b	c	d	e	11.	a	b	c	d	e
2.	a	b	c	d	e	12.	a	b	c	d	e
3.	a	b	c	d	e	13.	a	b	c	d	e
4.	a	b	c	d	e	14.	a	b	c	d	e
5.	a	b	c	d	e	15.	a	b	c	d	e
6.	a	b	c	d	e	16.	a	b	c	d	e
7.	a	b	c	d	e	17.	a	b	c	d	e
8.	a	b	c	d	e	18.	a	b	c	d	e
9.	a	b	c	d	e	19.	a	b	c	d	e
10.	a	b	c	d	e	20.	a	b	c	d	e

GOOD LUCK

$$D = \frac{m}{V}$$

$$\rightarrow V = \frac{m}{D}$$

$$M = \frac{d \times \% \times 10}{MM}$$

1. Calculate the density of 54.3 (wt/wt %) aqueous NaOH (molar mass = 40.00 g/mole) if you know that this solution is 19.2M.

- a) 2.96 g ml⁻¹ b) 1.41 g ml⁻¹ c) 2.83 g ml⁻¹
d) 1.46 g ml⁻¹ e) 1.52 g ml⁻¹

2. Brine water contains an average of 1.08×10^3 ppm of Na⁺ (molar mass 23 g/mol), given that the density of the brine is 1.06 g/mL, Calculate the species (equilibrium) molar concentration of Na⁺:

- a) 0.0500 M b) 0.0369 M c) 0.0925 M d) 1.01 M
e) 0.0759 M

$$M = \frac{\text{mol}}{V} = \frac{0.0469}{10^3} \times \frac{10^3}{1.06}$$

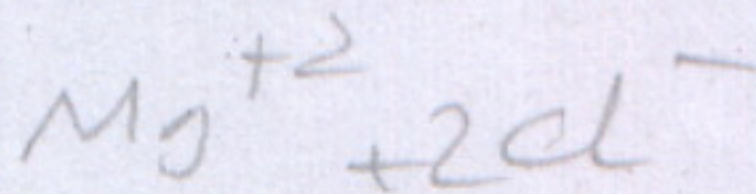
3. Calculate the pOH in a solution that is 6.20×10^{-3} M Ba(OH)₂ and 2.31×10^{-2} M in NaOH:

- a) 2.671 b) 2.400 c) 1.123 d) 3.619 e) 1.450

4. A solution was prepared by dissolving 7.56 g of KCl.MgCl₂.6H₂O (molar mass = 277.85 g/mol) in sufficient water to give 3.00 L solution. Calculate:

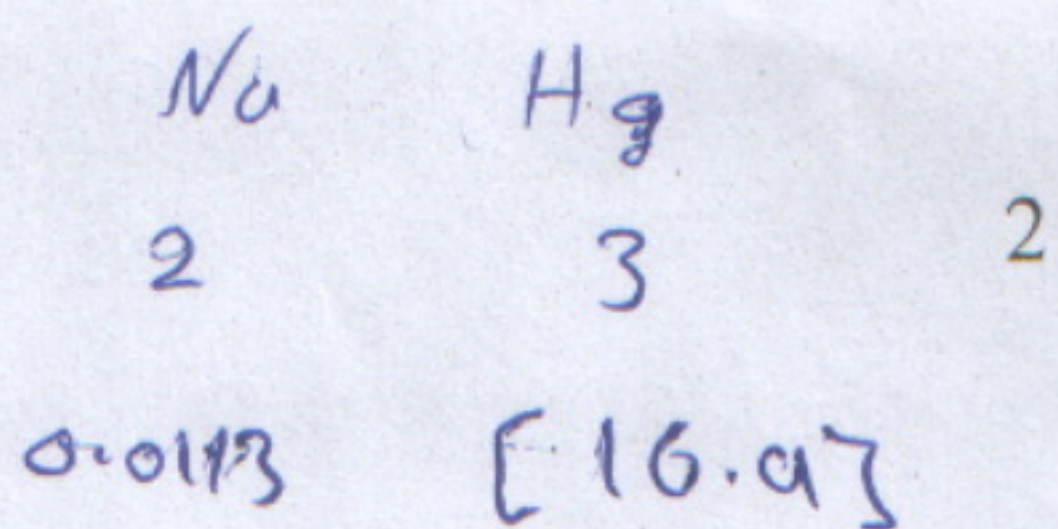
the molar analytical concentration of KCl.MgCl₂ in this solution.

- a) 1.06×10^{-6} M b) 3.2×10^{-5} M c) 9.07×10^{-3} M
d) 2.77×10^{-2} M e) 1.32×10^{-4} M



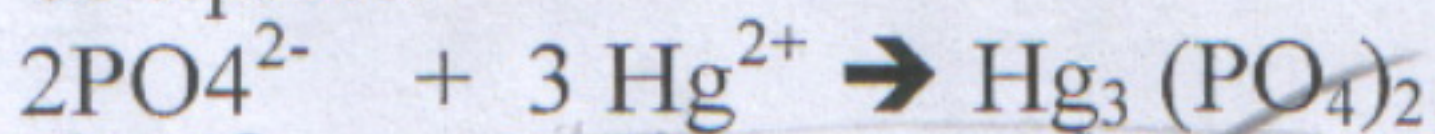
5. For question no. 4 above calculate the ppm of Mg²⁺ (molar mass = 24.3 g/mol).

- a) 150.1 b) 220.4 c) 20.9 d) 304.1 e) 73.5



$$51.51 - 16.9 = 34.6 / 130 = \textcircled{b}$$

6. When a 30.0 mL of 0.3757 M solution of Na_3PO_4 were mixed with 100.0 mL of 0.5151 M $\text{Hg}(\text{NO}_3)_2$, calculate the molarity of the unreacted species (Na_3PO_4 or $\text{Hg}(\text{NO}_3)_2$) after the reaction was complete:



- a) 0.0917M
 b) 0.266 M
 c) 0.118 M
 d) 3.20×10^{-2} M
 e) 8.23×10^{-5} M

$$\begin{aligned} \text{Mol} &= 11.2 \\ &= 5.6 \text{ Mol} \\ \text{Mol} &= 51.51 \\ &= 7.17 \end{aligned}$$

7. The correct statement among the following is:

- a) Proportional errors have the same magnitude regardless of sample size.
 b) All analytical measurements have determinate errors.
 c) Random errors are evaluated by the closeness of measured values to the true value.
 d) Constant errors should have the same magnitude regardless of the sample size.
 e) Determinate errors are mathematically expressed by the CV(%).

8. Suppose that 0.1 mg of a precipitate was lost as a result of being washed with 300 mL of wash liquid. If the precipitate weighed 500mg, encircle the correct statement:

- a) The relative error due to solubility loss is +2.0%.
 b) The above information should lead to a conclusion regarding relative precision.
 c) An increase in replicate measurements should increase precision.
 d) An increase in replicate measurements should increase accuracy.
 e) None of the statements above are correct.

9. The result of the calculation $[\log 7.230 \times 10^9]$ is reported as
- a) 9.86 b) 9.859 c) 9.8591 d) 9.85910 e) 9.859100

10. Consider the following mathematical operation

$$\frac{157(\pm 6) - 59(\pm 3)}{1220(\pm 1) + 77(\pm 8)} = 0.075559$$

$$\frac{98 \pm 6.708}{1297 \pm 8.0623}$$

Upon calculation of the standard deviation, the result of the calculation is reported as

- a) 0.076 (± 0.005) b) 0.09 (± 0.01) c) 0.0757 (± 0.0002)
d) 0.07573 (± 0.00008) e) 0.1 (± 0.1)

11. The following results were obtained in the replicate determination of the lead content of a blood sample: 0.752, 0.756, 0.752, 0.751 and 0.756 ppm $\bar{x} = 0.7534$ Pb. Given that $s = 0.004$ Pb, calculate the standard error of the mean.

- a) 0.004 b) 0.008 c) 0.002 d) 0.1 e) 1

12. Analysis of two samples for their potassium content yielded the following data:

Sample	No. of replicate results	Percent potassium
1	4	5.15, 5.03, 5.04, 5.85
2	3	7.18, 7.17, 6.97

$$\bar{x} = 5.2675$$

$$s = 7.106$$

$$7.2$$

$$sum(1) = 0.461$$

$$sum(2) = 0.0280$$

The pooled standard deviation, S_{pooled} for these data is

- a) 0.74 b) 0.15 c) 0.31 d) 0.082 e) 0.96

$$CV = \frac{s}{\bar{x}} \times 100\%$$

13. Consider the following set of data $\bar{x} = 0.4984$
0.514, 0.503, 0.486, 0.497, and 0.492. Given that the standard deviation, $s=0.011$. Calculate the coefficient of variation for this set of data

$$CV = \frac{s}{\bar{x}} \times 100\%$$

$$\frac{0.011}{0.4984} \times 100\% = 2.2\%$$

- a) 0.15% b) 11% c) 7.1% d) 13% e) 2.2%

14. The following measurements for dissolved oxygen in a river water are 4.90, 5.10, 5.60, 4.30, 4.70, 4.90, 4.50 and 5.10. Given that a pooled estimate the standard deviation, $S_{\text{pooled}} \rightarrow \sigma = 0.40$, calculate the 90% confidence limits for these data

$$\bar{x} = 4.8$$

- a) 4.90 ± 0.72 b) 4.90 ± 0.11 c) 4.90 ± 0.56
d) 4.90 ± 0.23 e) 4.90 ± 0.09

$$CI = \bar{x} \pm \frac{t_s}{\sqrt{n}} = 4.8 \pm \frac{0.4 \times 1.86}{\sqrt{8}}$$

15. The following data for mercury levels in a sample of polluted water were obtained. 1.00, 2.50, 3.00, 3.50, 4.00, 4.25, 4.50, 4.75, 6.75 ppm. The result that should be rejected at the 90% confidence level is

- a) 1.00 ppm b) 2.50 c) 6.75 d) 4.00 e) none

$$-(-0.437) \text{ لحدود}$$

16. The confidence interval increases with

$$CI = \frac{s}{\bar{x}} \times 100\%$$

- a) increasing standard deviation ✓
b) increasing number of results or measurements ✓
c) increasing number of degrees of freedom ✓
d) decreasing confidence level
e) all the above

$$CI = \bar{x} \pm \frac{t_s}{\sqrt{n}}$$

اعلى قيمة

$$\frac{Q_{\text{test}} - Q_{\text{crit}}}{Q_{\text{test}}}$$

$$Q_{\text{test}}$$

$$K_{sp} = [Pb][I]^2$$

17. Calculate the solubility of PbI_2 in a solution that is $0.010M$ NaI .

K_{sp} for PbI_2 is 1.0×10^{-17} .

- a) $1.0 \times 10^{-16} M$ b) $1.0 \times 10^{-13} M$ c) $1.0 \times 10^{-15} M$
 d) $1.6 \times 10^{-6} M$ e) $6.1 \times 10^{-6} M$

18. What is the hydroxide ion concentration of a $0.150 M$ NH_3 solution?

K_b for $NH_3 = 1.8 \times 10^{-5}$



- a) $1.64 \times 10^{-3} M$ b) $6.17 \times 10^{-12} M$ c) $1.15 \times 10^{-3} M$
 d) $8.70 \times 10^{-12} M$ e) None of the above

19. Calculate the pH change that takes place when a $100 mL$ portion of $0.0500 M$ $NaOH$ is added to $400 mL$ of a buffer solution that consists of $0.200 M$ HAc and $0.300 M$ $NaAc$?

K_a for $HAc = 1.8 \times 10^{-5}$

$$K_a = \frac{[Ac^-][H_3O^+]}{[HAc]}$$

- a) $\Delta pH = +0.05$ b) $\Delta pH = -0.05$ c) $\Delta pH = +0.01$
 d) $\Delta pH = -0.09$ e) $\Delta pH = -0.01$

$$pH = pK_a + \log \frac{[Ac^-]}{[HAc]}$$

$$= 4.938$$

20. What weight of sodium formate (molar mass = $68.0 g/mol$) must be added to $400.0 mL$ of $1.00 M$ formic acid to produce a buffer solution that has a pH of 3.50 ?

K_a for $HCOOH = 1.8 \times 10^{-4}$

(assume that addition of solid sodium formate does not change the volume of the solution)

- a) $19.5 g$ b) $23.0 g$ c) $14.5 g$ d) $15.5 g$ e) $1.95 g$

$$pH = pK_a + \log \frac{[A^-]}{[HA]}$$

$$3.50 = 3.74 + \log \frac{[x]}{1.00}$$

$$0.57$$

$$[x] = 0.564$$

Table 7-2

Values of t for Various Levels of Probability

Degrees of Freedom	Factor for Confidence Interval				
	80%	90%	95%	99%	99.9%
1	3.08	6.31	12.7	63.7	637
2	1.89	2.92	4.30	9.92	31.6
3	1.64	2.35	3.18	5.84	12.9
4	1.53	2.13	2.78	4.60	8.60
5	1.48	2.02	2.57	4.03	6.86
6	1.44	1.94	2.45	3.71	5.96
7	1.42	1.90	2.36	3.50	5.40
8	1.40	1.86	2.31	3.36	5.04
9	1.38	1.83	2.26	3.25	4.78
10	1.37	1.81	2.23	3.17	4.59
11	1.36	1.80	2.20	3.11	4.44
12	1.36	1.78	2.18	3.06	4.32
13	1.35	1.77	2.16	3.01	4.22
14	1.34	1.76	2.14	2.98	4.14
20	1.29	1.64	1.96	2.58	3.29

Table 9-1

Activity Coefficients for Ions at 25°C

Ion	α_x, nm	Activity Coefficient at Indicated Ionic Strength				
		0.001	0.005	0.01	0.05	0.1
H ₂ O ⁺	0.9	0.967	0.934	0.913	0.85	0.83
Li ⁺ , C ₆ H ₅ COO ⁻	0.6	0.966	0.930	0.907	0.83	0.80
Na ⁺ , IO ₃ ⁻ , HSO ₃ ⁻ , HCO ₃ ⁻ , H ₂ PO ₄ ⁻ , H ₂ AsO ₄ ⁻ , OAc ⁻	0.4-0.45	0.965	0.927	0.902	0.82	0.77
OH ⁻ , F ⁻ , SCN ⁻ , HS ⁻ , ClO ₃ ⁻ , ClO ₄ ⁻ , BrO ₃ ⁻ , IO ₄ ⁻ , MnO ₄ ⁻	0.35	0.965	0.926	0.900	0.81	0.76
K ⁺ , Cl ⁻ , Br ⁻ , I ⁻ , CN ⁻ , NO ₂ ⁻ , NO ₃ ⁻ , HCOO ⁻	0.3	0.965	0.925	0.899	0.81	0.75
Rb ⁺ , Cs ⁺ , Tl ⁺ , Ag ⁺ , NH ₄ ⁺	0.25	0.965	0.925	0.897	0.80	0.75
Mg ²⁺ , Be ²⁺	0.8	0.872	0.756	0.690	0.52	0.44
Ca ²⁺ , Cu ²⁺ , Zn ²⁺ , Sn ²⁺ , Mn ²⁺ , Fe ²⁺ , Ni ²⁺ , Co ²⁺ , Phthalate ²⁻	0.6	0.870	0.748	0.676	0.48	0.40
Sr ²⁺ , Ba ²⁺ , Cd ²⁺ , Hg ²⁺ , S ²⁻	0.5	0.869	0.743	0.668	0.46	0.38
Pb ²⁺ , CO ₃ ²⁻ , SO ₃ ²⁻ , C ₂ O ₄ ²⁻	0.45	0.868	0.741	0.665	0.45	0.36
Hg ₂ ²⁺ , SO ₄ ²⁻ , S ₂ O ₃ ²⁻ , CrO ₄ ²⁻ , HPO ₄ ²⁻	0.40	0.867	0.738	0.661	0.44	0.35
Al ³⁺ , Fe ³⁺ , Cr ³⁺ , La ³⁺ , Ce ³⁺	0.9	0.737	0.540	0.443	0.24	0.18
PO ₄ ³⁻ , Fe(CN) ₆ ³⁻	0.4	0.726	0.505	0.394	0.16	0.095
Th ⁴⁺ , Zr ⁴⁺ , Ce ⁴⁺ , Sn ⁴⁺	1.1	0.587	0.348	0.252	0.10	0.063
Fe(CN) ₆ ⁴⁻	0.5	0.569	0.305	0.200	0.047	0.020

Source: J. Kielland, *J. Am. Chem. Soc.*, 1937, 59, 1675. Courtesy of the American Chemical Society.Confidence Levels for Various Values of z

Number of Observations	Q_{crit} (Reject if $Q_{exp} > Q_{crit}$)		
	90% Confidence	95% Confidence	99% Confidence
3	0.941	0.970	0.994
4	0.765	0.829	0.926
5	0.642	0.710	0.821
6	0.560	0.625	0.740
7	0.507	0.568	0.680
8	0.468	0.526	0.634
9	0.437	0.493	0.598
10	0.412	0.466	0.568

Confidence Levels, %	z
50	0.67
68	1.00
80	1.29
90	1.64
95	1.96
95.4	2.00
99	2.58
99.7	3.00
99.9	3.29