30th International Chemistry Olympiad

Melbourne, Tuesday July 7, 1998

Laboratory Examination

Example Results and Marking Scheme

Official Version

Name: Team Code:

Laboratory Task 1 Results Sheet

Analysis of calcium/magnesium solution

Ca/Mg solution: **Blue Red Green Orange** (circle one)

Permanganate titration

Concentration of standard $KMnO_4$: ……**0.02039**…… M

Demonstrators Signature:……

max 2 marks for at least two witnessed precipitates

titration number:	**1**	**2**	**3**	
initial burette reading	0.90	0.80	3.00	mL
final burette reading	28.55	28.45	30.80	mL
volume of standard $KMnO_4$	27.65	27.65	27.80	mL

average titre = 27.70 mL ±0.07 mL av. dev. (ie ± 0.25% relative av. dev.)

In a 25 mL aliquot of dilute Ca/Mg solution:

$n(KMnO_4)$ required to titrate oxalate from dissolved calcium oxalate precipitate
= (0.0198 mol/L)(27.70 mL)/1000 mL/L = 5.485×10^{-4} mole

n(oxalate) from dissolved calcium oxalate precipitate
= 5/2 x 5.485×10^{-4} mole = 1.371×10^{-3} mole

-1 mark for incorrect stoichiometry

$n(Ca^{2+})$ from dissolved calcium oxalate precipitate = n(oxalate) = 1.371×10^{-3} mole

[Ca] = (1000 mL/L) 1.371×10^{-3} mole/25.00 mL = 0.0548 mol/L

In original Ca/Mg solution:

[Ca] = 0.0548 mol/L (1000 mL) / 25.00 mL = 0.548 mol/L

max 5 marks for correct calculation

Uncertainty in titre limits the uncertainty in [Ca] to 0.25% at least, or ±0.001 mol/L so 3 sig. figs at most. **-1 mark for less than 3 sig figs, -2 marks for more than 4 sig figs**

Accuracy (max 13 marks) - recalculated using student's data

Sliding scale. 13.00 marks for 0 to 1.5% deviation, zero marks for greater than 15%deviation.

Average concentration of Ca^{2+} in Ca/Mg solution: ……0.548…. M

20 marks

Name:	Team Code:

Laboratory Task 2 Results Sheet

Standardisation of ~0.0125 M NaOH

Concentration of standard HCl in bottle: .....**0.01253**..... M

titration number:	**1**	**2**	**3**	
aliquot of NaOH	25	25	25	mL
initial burette reading	13.60	17.40	10.35	mL
final burette reading	37.75	41.50	34.45	mL
volume of standard HCl	24.15	24.10	24.10	mL

average titre = 24.12 mL ±0.03 mL av. dev. (ie ± 0.12% relative av. dev.)

[NaOH] = (0.01250 mol/L)(24.12 mL)/(25.00 mL) = 0.01206 mol/L

Uncertainty is estimated few ppt so 4 sig. figs are justified.

-1 mark for less than 4 sig figs, -2 for more than 4 sig figs

-2 marks for incorrect calculation

Accuracy (max 5 marks) - recalculated using student's data

Sliding scale. 5.00 marks for 0 to 0.25% deviation, zero marks for greater than 5%deviation.

Average concentration of NaOH: ..... 0.01206..... M

5 marks

Name: Team Code:

Cobalt complex solution: **Blue Red Green Orange** (circle one)

Aliquot of cobalt complex solution used for ion-exchange: .....25..... mL

titration number:	**1**	**2**	**3**	
initial burette reading	26.25	16.10	3.80	mL
final burette reading	48.50	38.40	26.20	mL
volume of ion-exchanged acid solution	22.25	22.30	22.40	mL

Calculations

average titre of eluted acid = 22.32 mL ±0.06 mL av. dev. (± 0.25% rel. av. dev.)

[H^+ collected in 100 mL vol flask]
= (0.01206 mol NaOH/L)(25.00 mL)/(22.32 mL) = 0.01351mol/L

total n(H^+) collected from column
= 0.01351mol/L (100.0 mL)/(1000 mL/L) = 1.351×10^{-3} mol

n(H^+) from aliquot put onto column
= 0.00500 mol/L (25.00 mL)/(1000 mL/L) = 1.250×10^{-4} mol

-1 mark for neglect of HCl

n(H^+) ion-exchanged from complexes in aliquot put onto column
= 1.351×10^{-3} mol - 1.250×10^{-4} mol = 1.226×10^{-3} mol

let x = mass $[Co(NH_3)_5NO_2]Cl_2$ in 25.00 mL aliquot of mixture added to column

mass of mixture added to column = (25.00 mL/40 mL)(0.2000 g) = 0.1250 g

-1 mark for use of 0.2g only

then mass $[Co(NH_3)_6]Cl_3$ in aliquot = (0.1250 - x) g

n(H^+) ion-exchanged from $[Co(NH_3)_5NO_2]Cl_2$
= **2** (x g) / 261.00 g/mol = 0.007663 x mol **-2 for more than 4 sig figs**

n(H^+) ion-exchanged from $[Co(NH_3)_6]Cl_3$
= **3** (0.1250 - x) g / 267.50 g/mol
= (0.001402 - 0.011214 x) mol **-1 mark for neglect of cation charges**

so 0.007663 x + (0.001402 - 0.011214 x) = 0.001226 or x = 0.04956 g

so % $[Co(NH_3)_5NO_2]Cl_2$ = 100 (0.04956 g / 0.1250 g) = 39.6% w/w

5 marks for correct calculation

Accuracy (max 10 marks) - recalculated using student's data

Sliding scale. 10.00 marks for 0 to 2.00% deviation, zero marks for greater than 20%deviation.

Average percentage $[Co(NH_3)_5NO_2]Cl_2$ in sample: ... 39.6... % w/w

15 marks