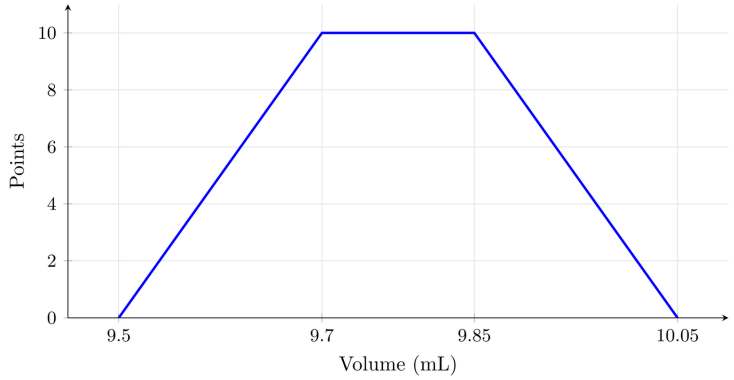
Kinetics of α-Chymotrypsin · Solutions

1.1 (10pt)



For V_{NaOH}:

$V_{NaOH} < 9.50$: 0 points

$9.50 \leq V_{NaOH} < 9.70$: points = 50*(V_{NaOH} − 9.50)

$9.70 \leq V_{NaOH} \leq 9.85$: 10 points

$9.85 < V_{NaOH} \leq 10.05$: points = 50*(10.05 − V_{NaOH})

$V_{NaOH} > 10.05$: 0 points

1.2 (1pt)

$$NaOH + HCl \rightarrow NaCl + H_2O$$

1pt for correct reaction equation

1.3 (1pt)

$$C_{NaOH} = \frac{0.0480 \cdot 10.0}{V_{NaOH}(mL)}.$$

1pt for correct calculation of concentration

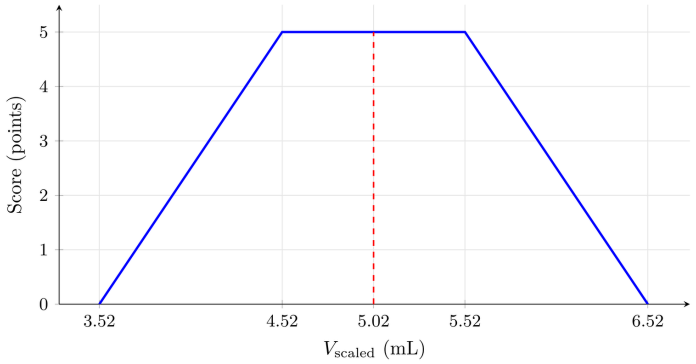
1.4 (20pt)

The volume of NaOH reported by the student will be scaled to 20 ºC using the reported volume and temperature to account for faster reactions at higher temperatures:

#	C_0, M	[ATEE], M	T, ℃	V_{NaOH}, mL	V_{scaled}
1	0.0200	0.0100	T_1	V_1	$V_{1.scaled} = V_1 + 0.281(20 - T_1)$
2	0.0100	0.0050	T_2	V_2	$V_{2,scaled} = V_2 + 0.281(20 - T_2)$
3	0.0067	0.0033	T_3	V_3	$V_{3,scaled} = V_3 + 0.281(20 - T_3)$
4	0.0050	0.0025	T_4	V_4	$V_{4,scaled} = V_4 + 0.281(20 - T_4)$

Each measurement is worth 5 points.

For #1:



$V_{scaled} < 3.52$: 0 points

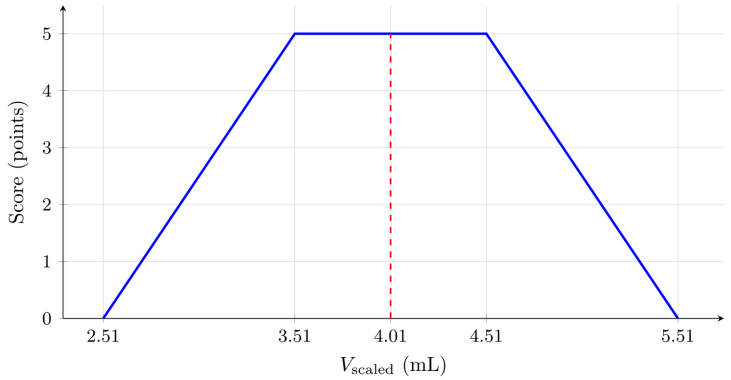
$3.52 \leq V_{scaled} < 4.52$: points = 5*($V_{scaled}$ − 3.52)

$4.52 \leq V_{scaled} \leq 5.52$: 5 points

$5.52 < V_{scaled} \leq 6.52$: points = 5*(6.52 − V_{scaled})

$V_{scaled} > 6.52$: 0 points

For #2:



$V_{scaled} < 2.51$: 0 points

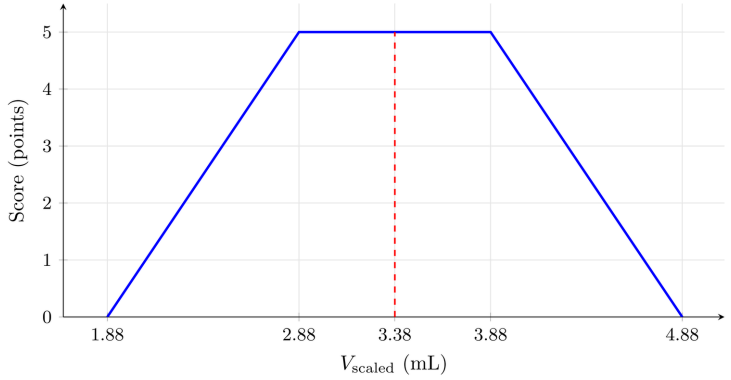
$2.51 \leq V_{scaled} < 3.51$: points = $5*(V_{scaled} - 2.51)$

$3.51 \leq V_{scaled} \leq 4.51$: 5 points

$4.51 < V_{scaled} \leq 5.51$: points = $5*(5.51 - V_{scaled})$

$V_{scaled} > 5.51$: 0 points

For #3:



$V_{scaled} < 1.88$: 0 points

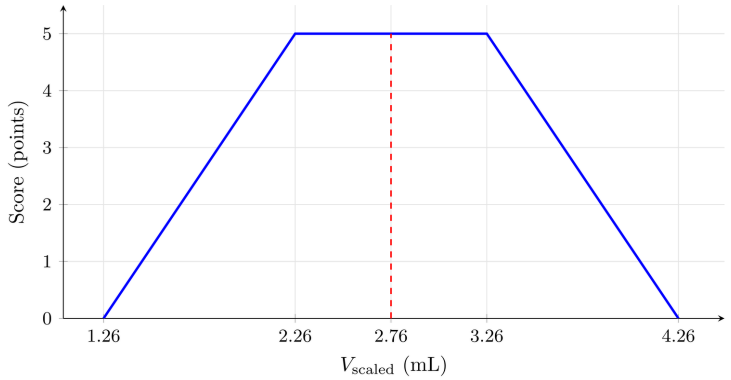
$1.88 \leq V_{scaled} < 2.88$: points = $5*(V_{scaled} - 1.88)$

$2.88 \leq V_{scaled} \leq 3.88$: 5 points

$3.88 < V_{scaled} \leq 4.88$: points = $5*(4.88 - V_{scaled})$

$V_{scaled} > 4.88$: 0 points

For #4



$V_{scaled} < 1.26$: 0 points

$1.26 \leq V_{scaled} < 2.26$: points = 5*($V_{scaled}$ − 1.26)

$2.26 \leq V_{scaled} \leq 3.26$: 5 points

$3.26 < V_{scaled} \leq 4.26$: points = 5*(4.26 − V_{scaled})

$V_{scaled} > 4.26$: 0 points

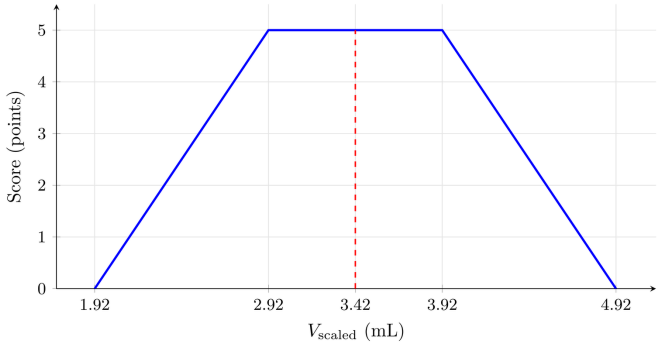
1.5 (15pt)

The volume of NaOH reported by the student will be scaled to 20 ºC using the reported volume and temperature to account for faster reactions at higher temperatures:

#	C_0, M	[*ATEE*], M	[*I*], μM	*T*, °C	V_{NaOH}, mL	V_{scaled}
5	0.0100	0.0050	0.29	T_5	V_5	$V_{5,scaled} = V_5 + 0.178 * (20 - T_5)$
6	0.0100	0.0050	0.58	T_6	V_6	$V_{6,scaled} = V_6 + 0.057 * (20 - T_6)$
7	0.0100	0.0050	0.87	T_7	V_7	$V_{7,scaled} = V_7 + 0.041 * (20 - T_7)$

Each measurement is worth 5 points.

For #5:



V_{scaled} < 1.92: 0 points

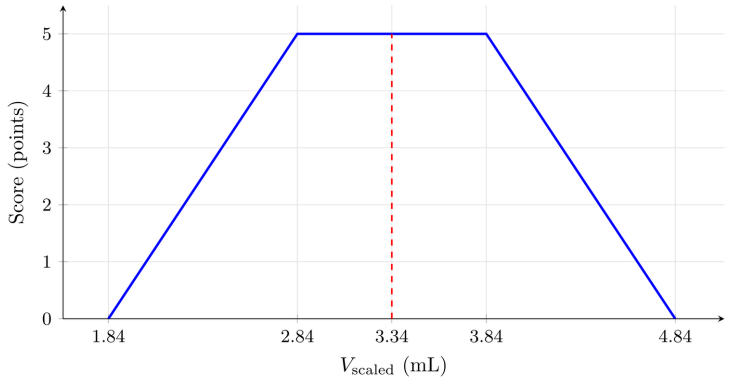
1.92 ≤ V_{scaled} < 2.92: points = 5*(V_{scaled} − 1.92)

2.92 ≤ V_{scaled} ≤ 3.92: 5 points

3.92 < V_{scaled} ≤ 4.92: points = 5*(4.92 − V_{scaled})

V_{scaled} > 4.92: 0 points

For #6:



$V_{scaled} < 1.84$: 0 points

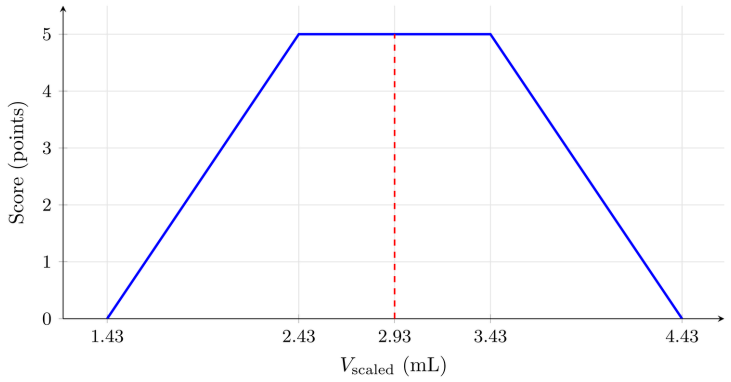
$1.84 \leq V_{scaled} < 2.84$: points = 5*($V_{scaled}$ − 1.84)

$2.84 \leq V_{scaled} \leq 3.84$: 5 points

$3.84 < V_{scaled} \leq 4.84$: points = 5*(4.84 − V_{scaled})

$V_{scaled} > 4.84$: 0 points

For #7:



$V_{scaled} < 1.43$: 0 points

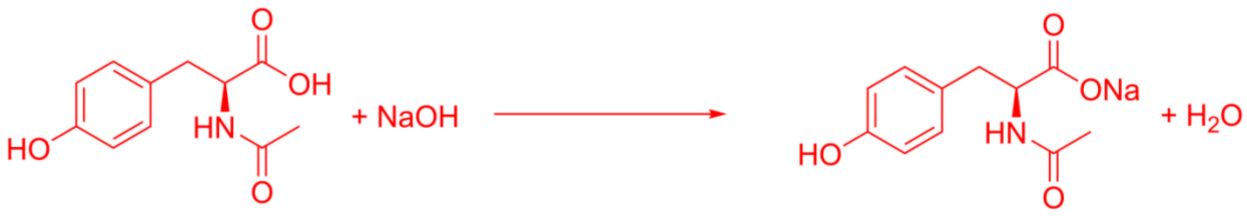
$1.43 \leq V_{scaled} < 2.43$: points = 5*($V_{scaled}$ − 1.43)

$2.43 \leq V_{scaled} \leq 3.43$: 5 points

$3.43 < V_{scaled} \leq 4.43$: points = 5*(4.43 − V_{scaled})

$V_{scaled} > 4.43$: 0 points

1.6 (1pt)



1.7 (2pt)

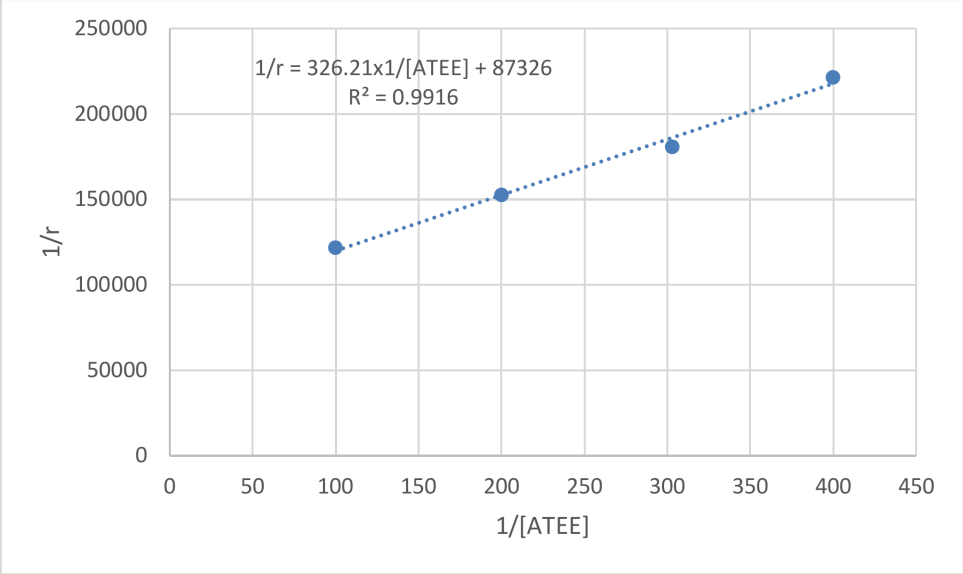
$$r = \frac{0.0480 \cdot 10.0 \cdot V_{NaOH}(mL\ for\ AT)}{V_{NaOH}(mL\ for\ HCl) \cdot 1000 \cdot 0.1 \cdot 5 \cdot 60}$$

#	[ATEE], M	$\frac{1}{[ATEE]}$, M^{-1}	[I], μM	r, M s^{-1}	$\frac{1}{r}$, M^{-1} s
1	0.0100	100	0	8.21×10^{-6}	121763
2	0.0050	200	0	6.56×10^{-6}	152431
3	0.0033	300	0	5.53×10^{-6}	180843
4	0.0025	400	0	4.52×10^{-6}	221467
5	0.0050	200	0.29	5.59×10^{-6}	178728
6	0.0050	200	0.58	5.46×10^{-6}	183009
7	0.0050	200	0.87	4.79×10^{-6}	208618

1 pt for each correct column.

1.8 (3pt)

$$\frac{1}{r} = \frac{K_M}{r_{max}} \times \frac{1}{[ATEE]} + \frac{1}{r_{max}}$$



$r_{max} = \frac{1}{87326} = 1.15 \times 10^{-5}\ \frac{\text{M}}{\text{s}}$

$K_M = 326.21 \times r_{max} = 3.75 \times 10^{-3}$ M

1pt for corresponding plot from the table.

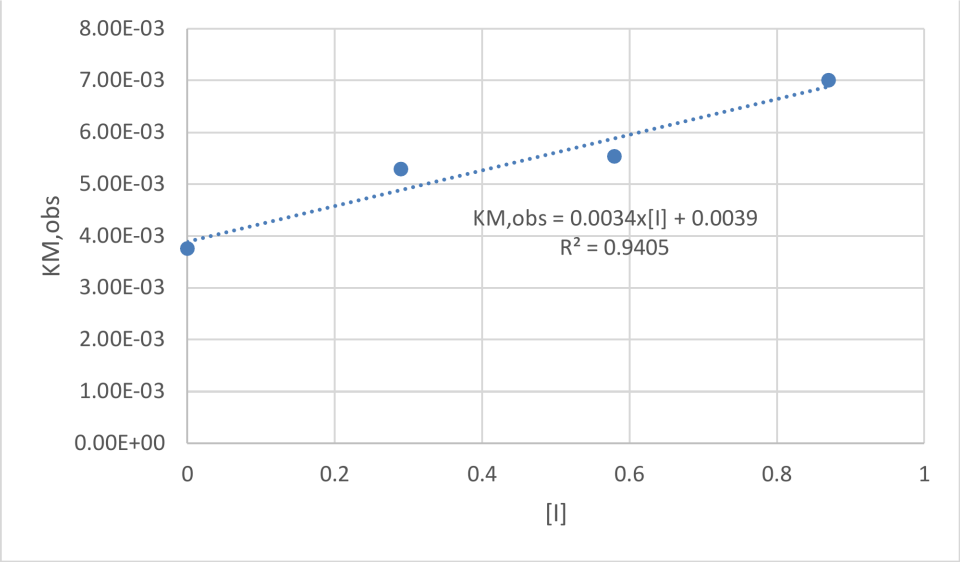
1 pt for correct r_{max} obtained from the plot.

1pt for correct K_M obtained from the plot.

1.9 (3pt)

#	[I], μM	$K_{M,obs}$, M
5	0.29	5.28×10^{-3}
6	0.58	5.52×10^{-3}
7	0.87	7.00×10^{-3}

When [I] = 0 $\rightarrow K_{M,obs} = K_M$, which is added as 4th point.



$$K_I = \frac{K_M}{0.0034} \times 10^{-6} = 1.10 \times 10^{-6}\ \text{M}$$

1pt for correct column in the table.

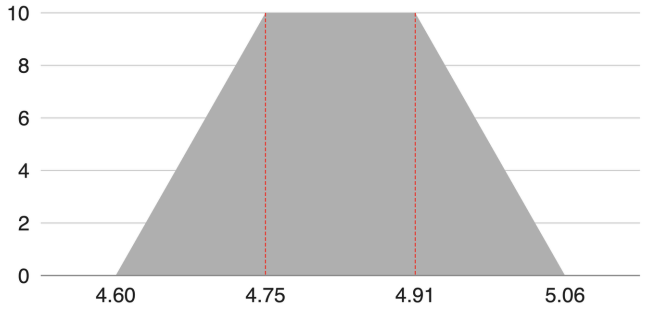
1pt for the corresponding plot from the table.

1pt for correct K_I obtained from the plot.

Zeolites as ‘Molecular Sieves’ · Solutions

2.1 (10pt)

Students’ titration volumes are graded as follows:



$V_1^{EDTA} < 4.60$	0 points
$4.60 < V_1^{EDTA} < 4.75$	$P = 10 - 66.67 \times (4.75 - V_1^{EDTA})$
$4.75 < V_1^{EDTA} < 4.91$	10 points
$4.91 < V_1^{EDTA} < 5.06$	$P = 10 - 66.67 \times (V_1^{EDTA} - 4.91)$
$V_1^{EDTA} > 5.06$	0 points

2.2 (1pt)

$$Ca^{2+} + H_2Y^{2-} \rightarrow CaY^{2-} + 2H^+$$

For correct answer 1 point.

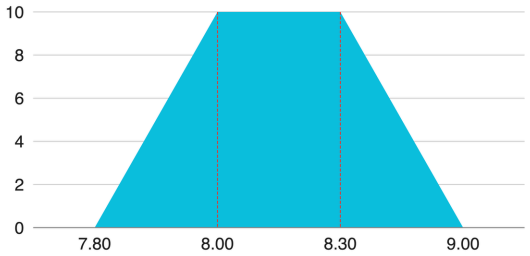
2.3 (1pt)

$$C_{CaCl_2} = \frac{0.1000 \cdot V_1^{EDTA}(mL)}{10.0}$$

For correct answer 1 point.

2.4 (10pt)

The **Titration volume** in this task is calculated as follows because as zeolite mass increases the amount of absorbed calcium will be higher. Hence, less EDTA solution will be needed to titrate the smaller amount of remaining calcium. The V_2^{EDTA} is divided by $m_{zeolite}$ to give a scaled volume to account for the different $m_{zeolite}$ for each student. The grading scheme is more generous for larger volumes, which can originate from not quantitatively transferring all of the zeolite out of the vial.



$\frac{V_2^{EDTA}}{m_{zeolite}} < 7.80$	0 points
$7.80 < \frac{V_2^{EDTA}}{m_{zeolite}} < 8.00$	$P = 10 - 50 \times (8.00 - \frac{V_2^{EDTA}}{m_{zeolite}})$
$8.00 < \frac{V_2^{EDTA}}{m_{zeolite}} < 8.30$	10 points

$8.30 < \frac{V_2^{EDTA}}{m_{zeolite}} < 9.00$	$P = 10 - 14.28 \times (\frac{V_2^{EDTA}}{m_{zeolite}} - 8.30)$
$\frac{V_2^{EDTA}}{m_{zeolite}} > 9.00$	0 points

2.5 (1pt)

$$Q_{Ca^{2+}} = \frac{50.0 \cdot (V_1^{EDTA} - V_2^{EDTA}) \cdot 0.1000}{10.0 \cdot m_{Zeolite\ 4A,\ \ Part\ A}}$$

For correct answer 1 point.

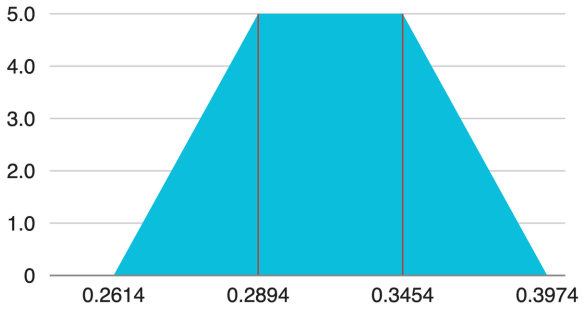
2.6 (12pt)

The **Absorbance** in this task is calculated as follows because as zeolite mass increases the amount of absorbed copper will be higher. Lower amounts of copper will lead to smaller absorbance. The A_{630} is divided by $m_{zeolite}$ to give a scaled absorbance to account for the different $m_{zeolite}$ for each student. For well 8, the grading scheme is more generous for larger absorbances, which can originate from not quantitatively transferring all of the zeolite out of the vial.

Solution	1	2	3	4	5	6	7
Well	A	B	C	D	E	F	G
A_{630} min	0.0083	0.0778	0.1469	0.2174	0.2864	0.3577	0.4232
A_{630} max	0.0583	0.1278	0.1969	0.2674	0.3364	0.4077	0.4732

1 point for each solution within the range. 0 points otherwise.

Well number 8 is graded as follows:



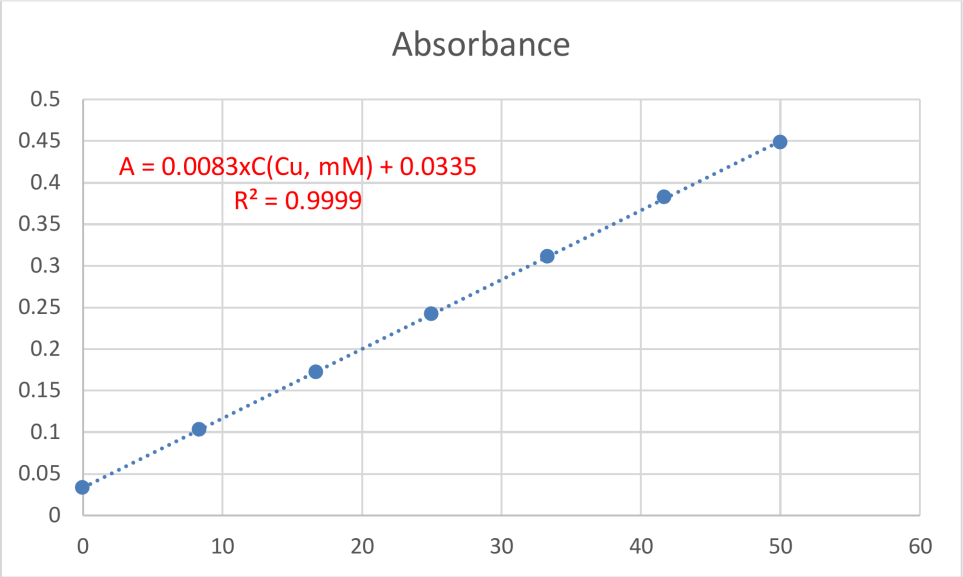
$\frac{A_{630}}{m_{zeolite}} < 0.2614$	0 points
$0.2614 < \frac{A_{630}}{m_{zeolite}} < 0.2894$	$P = 5 - 178.57 \times (0.2894 - \frac{A_{630}}{m_{zeolite}})$
$0.2894 < \frac{A_{630}}{m_{zeolite}} < 0.3454$	5 points
$0.3454 < \frac{A_{630}}{m_{zeolite}} < 0.3974$	$P = 5 - 96.15 \times (\frac{A_{630}}{m_{zeolite}} - 0.3454)$
$\frac{A_{630}}{m_{zeolite}} > 0.3974$	0 points

2.7 (1pt)

$$[Cu(H_2O)_6]^{2+} + 4NH_3 \rightarrow [Cu(NH_3)_4(H_2O)_2]^{2+} + 4H_2O$$

For correct reaction equation 1 point.

2.8 (1pt)



$$[Cu^{2+}] = \frac{A_{630} - 0.0335}{0.0083} \times 2 = 29.6 \text{ mM}$$

For correct answer 1 point.

2.9 (1pt)

$$Q_{Cu^{2+}} = \frac{(0.1000 - C_{Cu^{2+}}) \cdot 10.0}{m_{Zeolite\ 4A,\ Part\ B}}$$

For correct answer 1 point.

2.10 (1pt)

For the complete ion exchange ($Me^{2+} - Ca^{2+}$ or Cu^{2+}):

$$6Me^{2+} + Na_{12}Al_{12}Si_{12}O_{48} \cdot 27H_2O \rightarrow 12Na^{+} + Me_6Al_{12}Si_{12}O_{48} \cdot 27H_2O$$

For correct reaction equation 1 point.

2.11 (1pt)

$$Q_{max} = \frac{6 \cdot 1000}{2191.152} = 2.74 \text{ mmol g}^{-1}$$

For correct answer 1 point.

The adventures of Hodja Nasreddin continue · Solutions

3.1 (80pt)

A-F and **H** dissolve in water, while **G** does not. So, **G** could be $BaSO_4$, $CaCO_3$, or starch (which only dissolves in hot water).

The pairwise reactions of **A-F** and **H** solutions are as follows:

	A	B	C	D	E	F	H
A		-	-	-	↓ (white)	-	-
B			↑	-	-	-	↑
C				-	↑	-	-
D					-	-	-
E						-	↑
F							-
H							

From these water soluble substances, only $MgCO_3$ and S can be formed as white precipitates:

$$Mg^{2+} + CO_3^{2-} = MgCO_3 \downarrow$$

$$S_2O_3^{2-} + 2H^+ = S \downarrow + SO_2 \uparrow + H_2O$$

E forms white precipitate with **A**, and gases with **C** and **H**. So, **E** contains CO_3^{2-} or H^+. **B** also forms gases with **C** and **H**.

If **E** contains CO_3^{2-}, **A** – $MgSO_4$, **C** and **H** are acids (citric or ascorbic acid), **B** – $NaHCO_3$.

If **E** contains H^+, **A** – $Na_2S_2O_3$, **C** and **H** are $NaHCO_3$ and $2Na_2CO_3{\cdot}3H_2O_2$, **B** – citric or ascorbic acid. In this case **A** and **B** should form a precipitate of S, which is not observed.

So, **A** – $MgSO_4$, **B** – $NaHCO_3$, **C** and **H** are acids (citric or ascorbic acid), **E** – $2Na_2CO_3{\cdot}3H_2O_2$.

Addition of acids **C** or **H** to suspension of **G** results in gas formation. So, **G** – $CaCO_3$.

Addition of **E** ($2Na_2CO_3{\cdot}3H_2O_2$) to **D** with acids **C** or **H** doesn't result in any visible change.

Addition of **E** ($2Na_2CO_3{\cdot}3H_2O_2$) to **F** with acid **C** results in the appearance of a brown colour (I_2), while with acid **H** this doesn't result in any visible change. Additionally, addition of **H** to the I_2 containing solution leads to the loss of the of the brown colour due to the reduction of I_2. So, **C** – citric acid, **F** – KI, **H** – ascorbic acid.

Addition of **D** to **F** (KI) with **C** (citric acid) doesn't result in any visible change. So, **D** isn't $NaNO_2$, it is NaCl.

A	B	C	D	E	F	G	H
$MgSO_4$	$NaHCO_3$	Citric acid	NaCl	$2Na_2CO_3{\cdot}3H_2O_2$	KI	$CaCO_3$	Ascorbic acid

For each correct deciphered substance: 10 points.

If **G** is deciphered as $BaSO_4$ or starch: 3 points.

If **C** and **H** are deciphered as ascorbic acid and citric acid respectively: 3 points each.

If **B** and **E** are deciphered as $2Na_2CO_3{\cdot}3H_2O_2$ and $NaHCO_3$ respectively: 3 points each.

If **A** is deciphered as $Na_2S_2O_3$, **B** and **E** as any acid (ascorbic or citric), **C** and **H** as $NaHCO_3$ or $2Na_2CO_3{\cdot}3H_2O_2$: 3 points each.

3.2 (12pt)

i) contrast for X-ray examination of stomach – $BaSO_4$

ii) laxative – $MgSO_4$

iii) antacid to relieve indigestion – $NaHCO_3$

iv) gives the reddish colour to sausages – $NaNO_2$

v) table salt – NaCl

vi) chalk – $CaCO_3$

vii) holds moisture within dough – Starch

viii) prevents the browning of fruit – Ascorbic acid

ix) food preservative – Citric acid

x) dechlorination of water – $Na_2S_2O_3$

xi) laundry bleach – $2Na_2CO_3 \cdot 3H_2O_2$

xii) treatment of iodine deficiency – KI

For each correct match: 1 point.

3.3 (0pt)

No answer yet