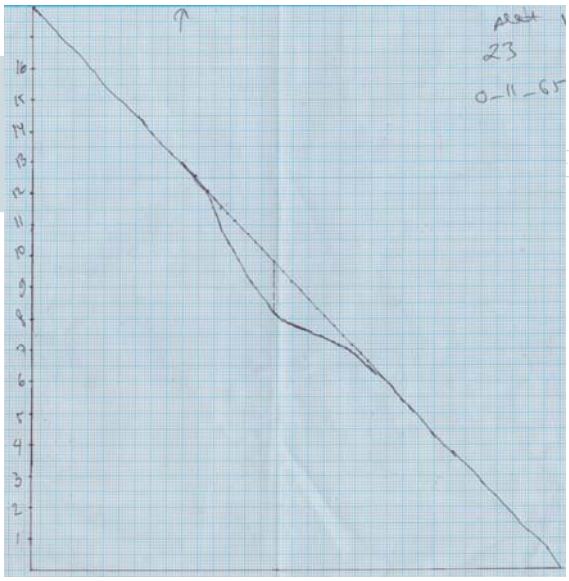
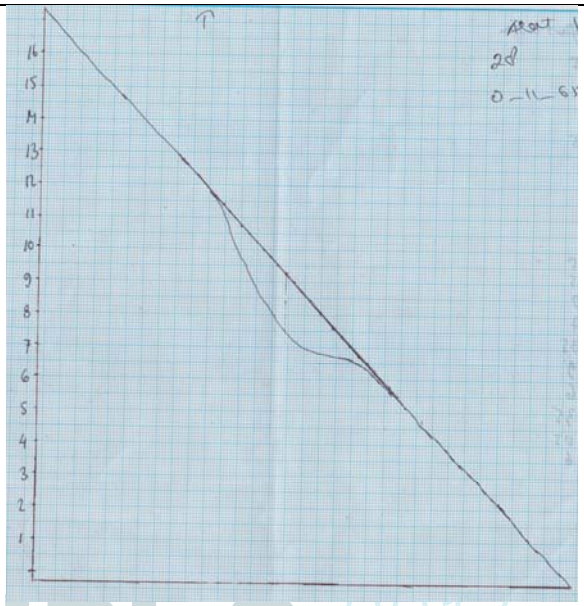
Determination of Refractive Index Gradient and Diffusion Coefficient of Salt Solution from Laser Deflection Measurement

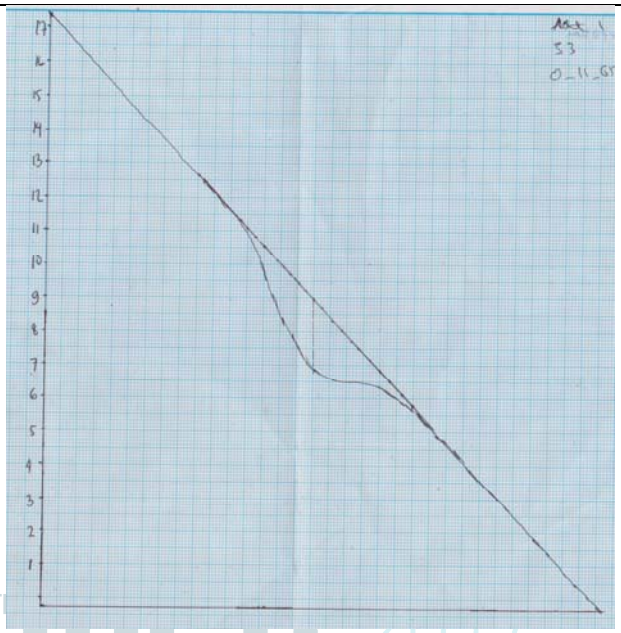
(10 points)

A. Measurement of Refractive Index Gradient of Salt Water Solution

(4.5 points)

Question	Answer	Marks
A1. **(1.2 pts)**	 **No dip** **No reference line** **Deflectogram (DL) not at the centre (+- 5mm) but the depth of dip still in 1.5 - 1.6 cm range** **DL at the centre, the depth of dip <1.5 cm or >1.6 cm** **DL not at the centre, the depth of dip <1.5 cm or >1.6 cm**	Deflectogram of C_0 = 23 g/150 mL Centred Depth of dip: 1.5 - 1.6 cm (0.4 pts) **-0.4** **-0.05** **-0.05** **-0.05** **-0.1**
		Deflectogram

A1.		of C_0 = 28 gr/150 mL Centred Deep of dip: 1.7 - 1.9 cm (0.4 pts)
	No dip	**-0.4**
	No reference line	**-0.05**
	Deflectogram (DL) not at the centre (+- 5mm) but the depth of dip still in 1.7 cm - 1.9 cm range	**-0.05**
	DL at the centre, the depth of dip <1.7 cm or >1.9 cm	**-0.05**
	DL not at the centre, the depth of dip <1.7 cm or >1.9 cm	**-0.1**

A1.	 **No dip** **No reference line** **Deflectogram (DL) not at the centre (+-5mm) but the depth of dip still in 1.9 - 2.3 cm range** **DL at the centre, the depth of dip <1.9 cm or >2.3 cm** **DL not at the centre, the depth of dip <1.9 cm or >2.3 cm**	Deflectogram of C_0 = 33 g/150 mL Deep of dip: 1.9 - 2.3 cm (0.4 pts) **-0.4 pts** **-0.05 pts** **- 0.05 pts** **- 0.05 pts** **-0.1**
A2. **(1.5 pts)**		Table 1 of C_0 = 23 g/150 mL Optimum Z and Z_0 # data = 20 (0.5 pts)

i	δ_i (cm)	ξ_i (cm)	Z_o (cm)	*d(cm)*	*Z (cm)*
1	0.05	11.55	10.4 ± 0. 1	0.8 ± 0.1	53.4 ± 0.1
2	0.35	11.3			
3	0.6	11.05			
4	0.9	10.85			
5	1	10.65			
6	1.1	10.35			
7	1.3	10.15			
8	1.4	9.85			
9	1.45	9.7			
10	1.5	9.45			
11	1.6	9.25			
12	1.5	8.95			
13	1.4	8.65			
14	1.2	8.35			
15	1	8.05			

16	0.8	7.75				
17	0.7	7.55				
18	0.5	7.25				
19	0.3	6.95				
20	0.2	6.65				
21	0.05	6.4				

Correct data point must be extracted from deflectogram -0.05 pts

correct data points >= 20, but not all observable (Z, Z0, d) are written -0.05 pts

Incorrect *d* -0.15 pts

15<= # correct data points<20, -0.3 pts

10<# correct data points<15 -0.45 pts

#correct data points<10

A2. Table 1 of C_0 = 28 g/150 mL

i	δ_i (cm)	ξ_i (cm)	Z_o (cm)	*d(cm)*	*Z (cm)*
1	0.05	11.65	10.4 ± 0. 1	0.8 ± 0.1	53.4 ± 0.1
2	0.25	11.4			
3	0.4	11.2			
4	0.8	11			
5	1	10.75			
6	1.2	10.4			
7	1.4	10.2			
8	1.5	10			
9	1.6	9.8			
10	1.7	9.5			
11	1.75	9.25			
12	1.7	8.95			
13	1.65	8.7			
14	1.5	8.4			
15	1.25	8.05			
16	0.9	7.6			
17	0.6	7.3			
18	0.4	7.05			
19	0.25	6.75			
20	0.05	6.3			

Optimum Z and Z_0

data = 20

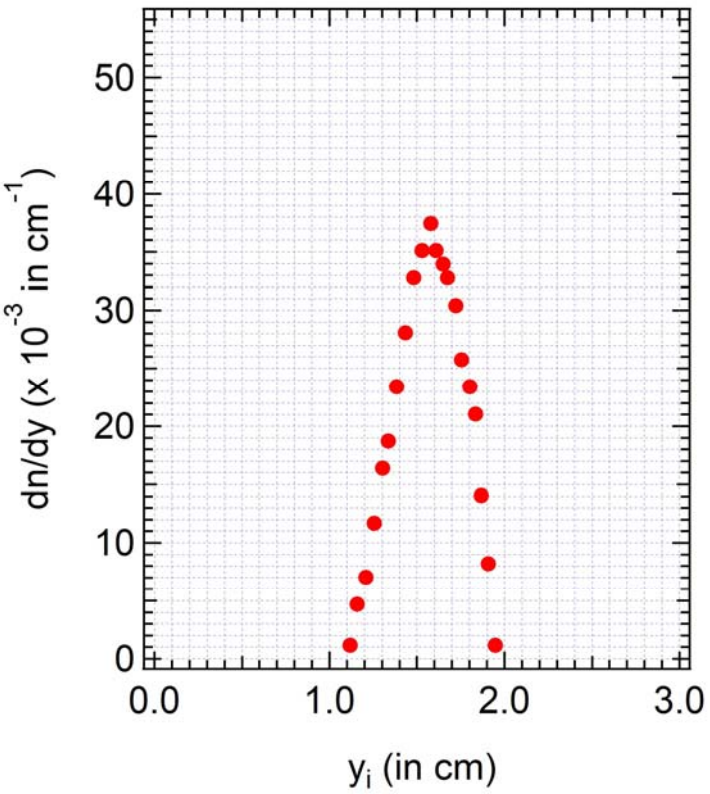
(0.5 pts)

	Correct data point must be extracted from deflectogram	
	# correct data points >= 20, but not all observable (Z, Z0, d) are written	-0.05 pts
	Incorrect *d*	-0.05 pts
	15<= # correct data points<20,	-0.15 pts
	10<# correct data points<15	-0.3 pts
	#correct data points<10	-0.45 pts
A2.	(table below)	Table 1 of C_0 = 33 g/150 mL # data point >= 20 (0.5 pts)

i	δ_i (cm)	ξ_i (cm)	Z_o (cm)	*d(cm)*	*Z (cm)*
1	0.05	11.6	10.4 ± 0. 1	0.8 ± 0.1	53.4 ± 0.1
2	0.15	11.4			
3	0.35	11.1			
4	0.65	10.85			
5	1.1	10.6			
6	1.3	10.4			
7	1.5	10.2			
8	1.7	10			
9	1.85	9.7			
10	2	9.5			
11	2.1	9.25			
12	2	9			
13	1.8	8.6			
14	1.5	8.3			
15	1.25	8.05			
16	1	7.8			
17	0.75	7.45			
18	0.55	7.15			
19	0.4	6.8			
20	0.2	6.4			
21	0.05	6.1			

Correct data point must be extracted from deflectogram	
# correct data points >= 20, but not all observable (Z, Z0, d) are written	-0.05 pts
Incorrect *d*	-0.05 pts
15<= # correct data points<20,	-0.15 pts

	10<# correct data points<15 #correct data points<10	-0.3 pts -0.45 pts
A3. **(1.5 pts)**	<table><tr><th>i</th><th>Y_i (cm)</th><th>dn/dY</th></tr><tr><td>1</td><td>1.85944</td><td>0.00117</td></tr><tr><td>2</td><td>1.81919</td><td>0.00819</td></tr><tr><td>3</td><td>1.77894</td><td>0.01404</td></tr><tr><td>4</td><td>1.74674</td><td>0.02106</td></tr><tr><td>5</td><td>1.71455</td><td>0.02340</td></tr><tr><td>6</td><td>1.66625</td><td>0.02574</td></tr><tr><td>7</td><td>1.63405</td><td>0.03043</td></tr><tr><td>8</td><td>1.58575</td><td>0.03277</td></tr><tr><td>9</td><td>1.56161</td><td>0.03394</td></tr><tr><td>10</td><td>1.52136</td><td>0.03511</td></tr><tr><td>11</td><td>1.48916</td><td>0.03745</td></tr><tr><td>12</td><td>1.44086</td><td>0.03511</td></tr><tr><td>13</td><td>1.39257</td><td>0.03277</td></tr><tr><td>14</td><td>1.34427</td><td>0.02809</td></tr><tr><td>15</td><td>1.29597</td><td>0.02340</td></tr><tr><td>16</td><td>1.24767</td><td>0.01872</td></tr><tr><td>17</td><td>1.21548</td><td>0.01638</td></tr><tr><td>18</td><td>1.16718</td><td>0.01170</td></tr><tr><td>19</td><td>1.11888</td><td>0.00702</td></tr><tr><td>20</td><td>1.07058</td><td>0.00468</td></tr><tr><td>21</td><td>1.03034</td><td>0.00117</td></tr></table> Jury must check the data in table # wrong data point < 3 3<# wrong data point < 6 # wrong data point > 6	Table 2 of C_0 = 23 g/150 mL. # data = 20 (0.25 pts) - 0 - 0.05 pts - 0.25pts

A3.	 No x-axis label No x-axis unit Without x-axis unit No y-axis label No y-axis unit Without y-axis unit Ordinate axis represented in 2 digid behind point Ordinate axis represented in 3 digid behind point Random shape	Plot dn/dY vs Y C_0 = 23 g/150 mL. "Gaussian-Like" shape (0.25 pts) -0.01 pts -0.01 pts -0.01 pts -0.01 pts -0.01 pts -0.01 pts -0.05 pts -0 pts -0.25 pts
A3.		Table 2 of C_0 = 28 g/150 mL. # data = 20

i	Y_i (cm)	dn/dY
1	1.87554	0.00117
2	1.83529	0.00585
3	1.80309	0.00936
4	1.77089	0.01872

5	1.73065	0.02340
6	1.67430	0.02809
7	1.64210	0.03277
8	1.60990	0.03511
9	1.57770	0.03745
10	1.52941	0.03979
11	1.48916	0.04096
12	1.44086	0.03979
13	1.40061	0.03862
14	1.35232	0.03511
15	1.29597	0.02926
16	1.22352	0.02106
17	1.17523	0.01404
18	1.13498	0.00936
19	1.08668	0.00585
20	1.01424	0.00117

(0.25 pts)

Jury must check the data in table

- 0

wrong data point < 3

- 0.05 pts

3<# wrong data point < 6

- 0.25pts

wrong data point > 6

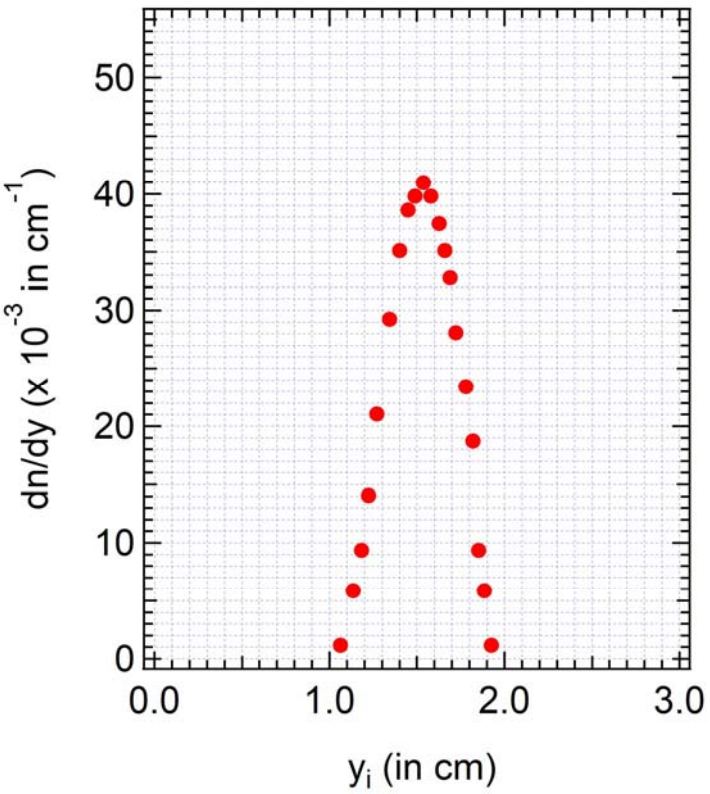
A3.

Plot dn/dY vs Y

C_0 = 28 g/150 mL.

"Gaussian-Like" shape

(0.25 pts)



	without x-axis label	-0.01 pts
	without x-axis unit	-0.01 pts
	wrong x-axis unit	-0.01 pts
	without y-axis label	-0.01 pts
	without y-axis unit	-0.01 pts
	wrong y-axis unit	-0.01 pts
	Ordinate axis represented in 2 digid behind point	-0.05 pts
	Ordinate axis represented in 3 digid behind point	-0 pts
	Random shape of the curve	-0.25 pts

A3.

i	Y_i (cm)	dn/dY
1	1.86749	0.00117
2	1.83529	0.00351
3	1.78699	0.00819
4	1.74674	0.01521
5	1.70650	0.02574

Table 2 of C_0 = 33 g/150 mL.

data = 20

	6	1.67430	0.03043
	7	1.64210	0.03511
	8	1.60990	0.03979
	9	1.56161	0.04330
	10	1.52941	0.04681
	11	1.48916	0.04915
	12	1.44891	0.04681
	13	1.38452	0.04213
	14	1.33622	0.03511
	15	1.29597	0.02926
	16	1.25572	0.02340
	17	1.19938	0.01755
	18	1.15108	0.01287
	19	1.09473	0.00936
	20	1.03034	0.00468
	21	0.98204	0.00117

(0.25 pts)

Jury must check the data in table

wrong data point < 3 — - 0

3<# wrong data point < 6 — - 0.05 pts

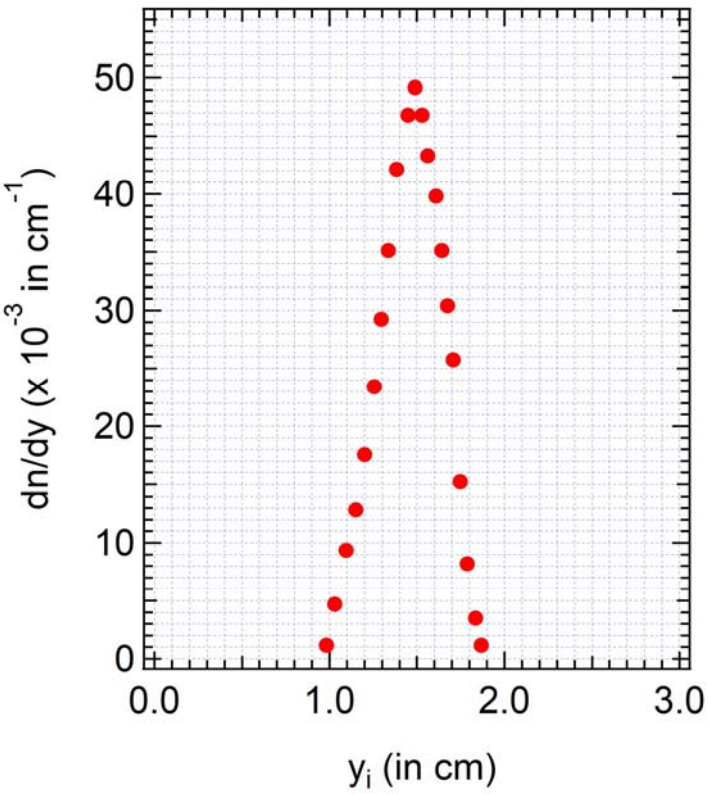
wrong data point > 6 — - 0.25pts

A3.

Plot dn/dY vs Y

C_0 = 33 g/150 mL.

(0.25 pts)

	 without x-axis label without x-axis unit wrong x-axis unit without y-axis label without y-axis unit wrong y-axis unit Ordinate axis represented in 2 digid behind point Ordinate axis represented in 3 digid behind point Random shape of the curve	-0.01 pts -0.01 pts -0.01 pts -0.01 pts -0.01 pts -0.01 pts -0.05 pts -0 pts -0.25 pts
A4. **(0.3 pts)**	*h* for 23 g/ 150 mL = (1.5 ± 0.1) cm	0.1 pts

	h for 28 g/ 150 mL = (1.5 ± 0.1) cm	0.1 pts
	h for 33 g/ 150 mL = (1.5 ± 0.1) cm	0.1 pts
	If h is correctly determined from graph A3 for each concentration	- 0
	If h is not correctly determined from graph A3 for each concentration	-0.1

B : Determination of Diffusion Coefficient (4.2 points)

Question	Answer	Marks
B1. **(0.9 pts)**	**Linear form of eq.(3)** $\ln\left(\frac{dn}{dY}\right) \approx m(h-Y)^2 + C$ (b1) $m = -\frac{1}{4D_e t}$ Constant : $C = \ln\left(\left(\frac{dn}{dc}\right)\left(\frac{C_0}{2\sqrt{\pi D_e t}}\right)\right)$ Other than (b1)	0.9 pt -0.9 pts
B2. **(1.8 pts)**		Table 3 of C_0 = 23 g /150 mL.

i	$(h-y_i)^2$	ln(dn/dy)
1	0.06592	-3.86003
2	0.050423	-3.75467
3	0.031065	-3.65936

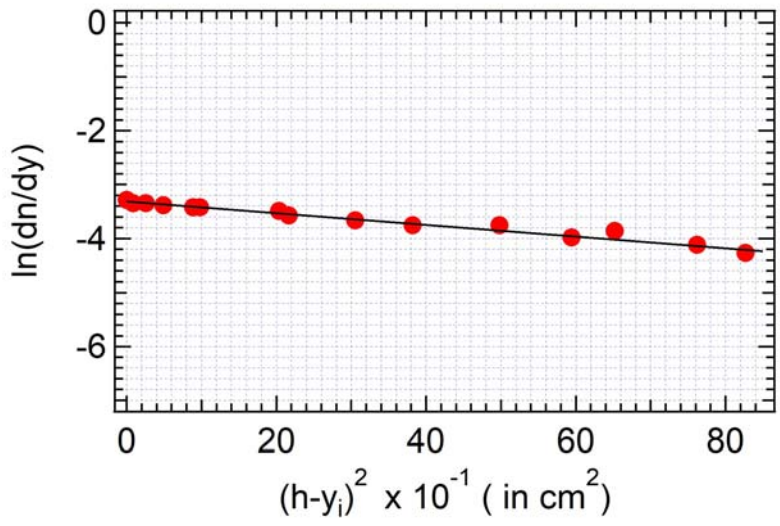
	4	0.020752	-3.4923
	5	0.00917	-3.41819
	6	0.005128	-3.3831
	7	0.000984	-3.3492
	8	6.99E-07	-3.28466
	9	0.002414	-3.3492
	10	0.009493	-3.41819
	11	0.021237	-3.57235
	12	0.037646	-3.75467
	13	0.05872	-3.97781

Jury must check the data in table

data = 10 (0.3 pts)

# of data point > 10	-0 pts
3 <= # of data point < 10	-0.05 pts
# of data point < 3	-0.3 pts
# wrong data point < 3	- 0
3<# wrong data point < 6	- 0.05 pts
# wrong data point >6	- 0.25 pts

B2



Plot of Table 3

C_0 = 23 g/150 mL

data = 10 (0.3pts)

Using linear regression of eq. (B1.1), we obtain

m (slope) = −10 cm^{-2} till −8.8 cm^{-2}

<table>
<tr>
<td></td>
<td>without x-axis label
without x-axis unit
wrong x-axis unit
without y-axis label
without y-axis unit
wrong y-axis unit

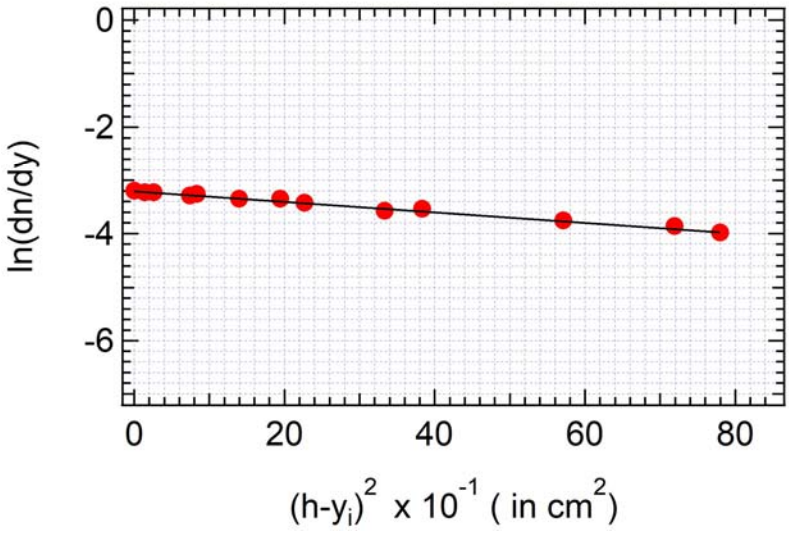
# of data point in linear range > 10
3 <= # of data point in linear range < 10
# of data point in linear range < 3 or random shape of curve
m is out of range</td>
<td>-0.01 pts
-0.01 pts
-0.01 pts
-0.01 pts
-0.01 pts
-0.01 pts

- 0
- 0.05 pts
- 0.25 pts
-0.3 pts</td>
</tr>
<tr>
<td>B2.</td>
<td>
<table>
<tr><th>i</th><th>$(h-yi)^2$</th><th>ln(dn/dy)</th></tr>
<tr><td>1</td><td>0.057912</td><td>-3.75467</td></tr>
<tr><td>2</td><td>0.033968</td><td>-3.57235</td></tr>
<tr><td>3</td><td>0.023136</td><td>-3.41819</td></tr>
<tr><td>4</td><td>0.014378</td><td>-3.3492</td></tr>
<tr><td>5</td><td>0.007693</td><td>-3.28466</td></tr>
<tr><td>6</td><td>0.001553</td><td>-3.22404</td></tr>
<tr><td>7</td><td>6.99E-07</td><td>-3.19505</td></tr>
<tr><td>8</td><td>0.002414</td><td>-3.22404</td></tr>
<tr><td>9</td><td>0.007989</td><td>-3.25389</td></tr>
<tr><td>10</td><td>0.018955</td><td>-3.3492</td></tr>
<tr><td>11</td><td>0.037646</td><td>-3.53152</td></tr>
<tr><td>12</td><td>0.071007</td><td>-3.86003</td></tr>
<tr><td>13</td><td>0.099079</td><td>-4.26549</td></tr>
</table>

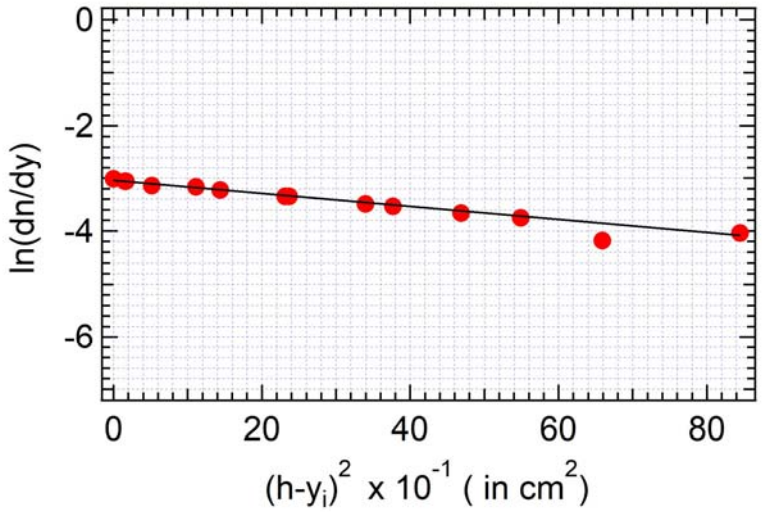
Jury must check the data in table</td>
<td>Table 3 of
C_0 = 28 g /150 mL

data = 10

(0.3 pts)</td>
</tr>
</table>

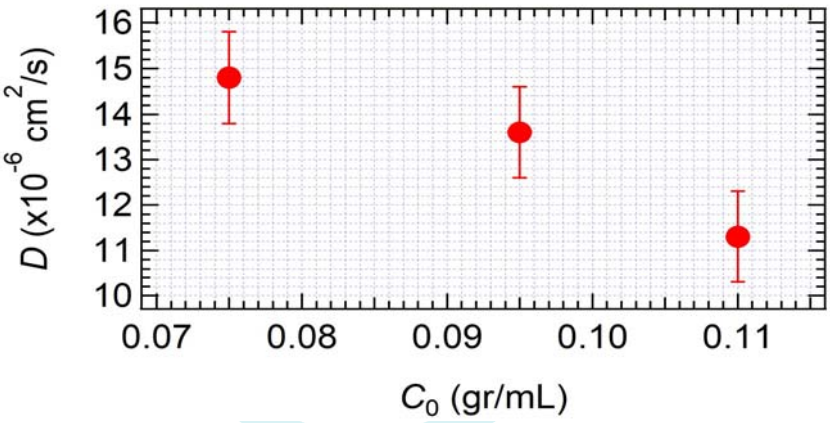
	# of data point > 10 3 <= # of data point < 10 # of data point < 3 # wrong data point < 3 3<# wrong data point < 6 # wrong data point >6	-0 pts -0.05 pts -0.3 pts - 0 - 0.05 pts - 0.25 pts
B2.	 Using linear regression of eq. (B1.1), we obtain m (slope) = −10.3 cm^{-2} till −11 cm^{-2} without x-axis label without x-axis unit wrong x-axis unit without y-axis label without y-axis unit wrong y-axis unit	Plot of Table 3 C_0 = 28 g/150 mL # data = 10 (0.3pts) -0.01 pts -0.01 pts -0.01 pts -0.01 pts -0.01 pts -0.01 pts -0 pts

<table>
<tr><td></td><td># of data point in linear range > 10
3 <= # of data point in linear range < 10
# of data point in linear range < 3 or random shape of curve
m is out of range</td><td>-0.05 pts
-0.3 pts
-0.3 pts</td></tr>
<tr><td>B2.</td><td>
<table>
<tr><th>i</th><th>$(h-y_i)^2$</th><th>ln(dn/dy)</th></tr>
<tr><td>1</td><td>0.046873</td><td>-3.65936</td></tr>
<tr><td>2</td><td>0.033968</td><td>-3.4923</td></tr>
<tr><td>3</td><td>0.023136</td><td>-3.3492</td></tr>
<tr><td>4</td><td>0.014378</td><td>-3.22404</td></tr>
<tr><td>5</td><td>0.005128</td><td>-3.13948</td></tr>
<tr><td>6</td><td>0.001553</td><td>-3.06152</td></tr>
<tr><td>7</td><td>6.99E-07</td><td>-3.01273</td></tr>
<tr><td>8</td><td>0.001688</td><td>-3.06152</td></tr>
<tr><td>9</td><td>0.011126</td><td>-3.16688</td></tr>
<tr><td>10</td><td>0.023647</td><td>-3.3492</td></tr>
<tr><td>11</td><td>0.037646</td><td>-3.53152</td></tr>
<tr><td>12</td><td>0.054884</td><td>-3.75467</td></tr>
<tr><td>13</td><td>0.08446</td><td>-4.04235</td></tr>
</table>
Jury must check the data in table
# of data point > 10
3 <= # of data point < 10
# of data point < 3
wrong data point < 3
3<# wrong data point < 6
wrong data point >6</td><td>Table 3 of
C_0 = 33 g /150 mL
data = 10
(0.3 pts)
-0 pts
-0.05 pts
-0.3 pts
- 0
- 0.05 pts
- 0.25</td></tr>
<tr><td>B2.</td><td></td><td>Plot of Table 3
C_0 = 33 g/150 mL</td></tr>
</table>

	 Using linear regression of eq. (B1.1), we obtain *m* (slope) = −11.3 cm^{-2} till −12.8 cm^{-2} without x-axis label without x-axis unit wrong x-axis unit without y-axis label without y-axis unit wrong y-axis unit m is out of range # of data point in linear range > 10 3 <= # of data point in linear range < 10 # of data point in linear range < 3 or random shape of curve	# data = 10 (0.3pts) -0.01 pts -0.01 pts -0.01 pts -0.01 pts -0.01 pts -0.01 pts -0.3 pts -0 pts -0.05 pts -0.3
B3 **(1.5 pts)**	*D* of 23 g/ 150 mL = (1.38 till 1.58) x 10^{-5} cm^2/s *D* of 28 g/ 150 mL = (1.26 till 1.46) x 10^{-5} cm^2/s	0.5 pts 0.5 pts

	D of 33 g/ 150 mL = (1.03 till 1.23) x 10^{-5} cm^2/s D is out of range for each concentration	0.5 pts- -0.5 pts

C. Nonlinear diffusion (1.3 points)

Question	Answer	Marks
C1. **(1.3 pts)**	 Without error bars **Value of C not stated in $C_0/2$**	Plot D vs. C_0 0.8 pts -0 -0.4 pts
C1.	$\frac{d}{dC}D = -4.2 \times 10^{-5} cm^2\ mL\ g^{-1}s^{-1}$ till $-15.8 \times 10^{-5} cm^2\ mL\ g^{-1}s^{-1}$ Without or wrong unit Out of range	0.5 pts -0.01 pts -0.5 pts