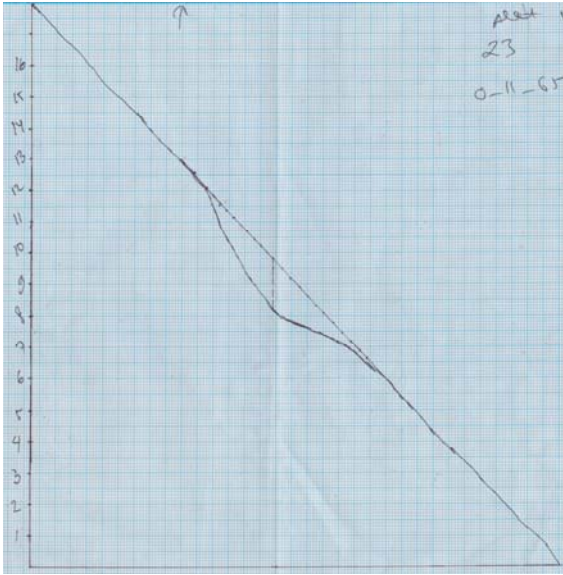


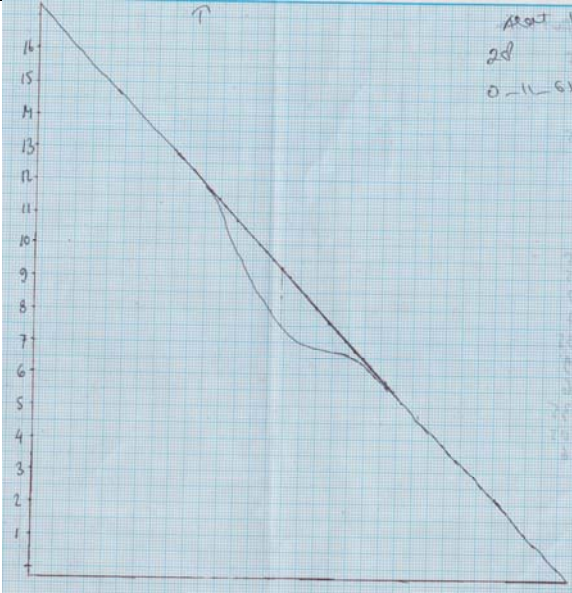
Determination of Refractive Index Gradient and Diffusion Coefficient of Salt Solution from Laser Deflection Measurement

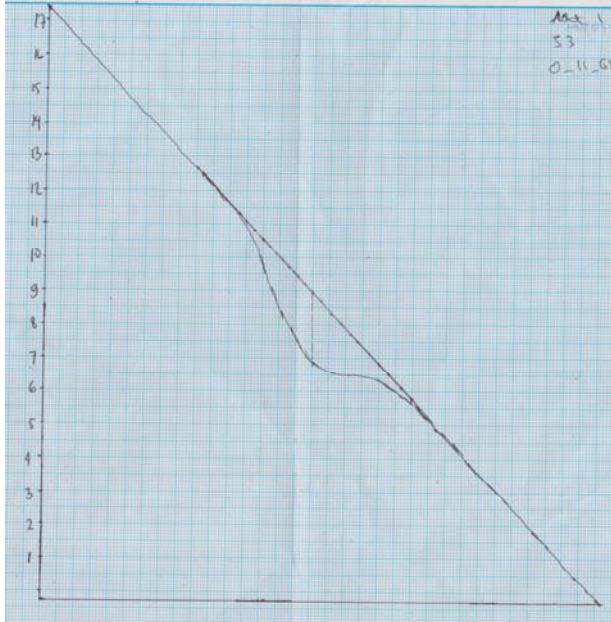
(10 points)

A. Measurement of Refractive Index Gradient of Salt Water Solution

(4.5 points)

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

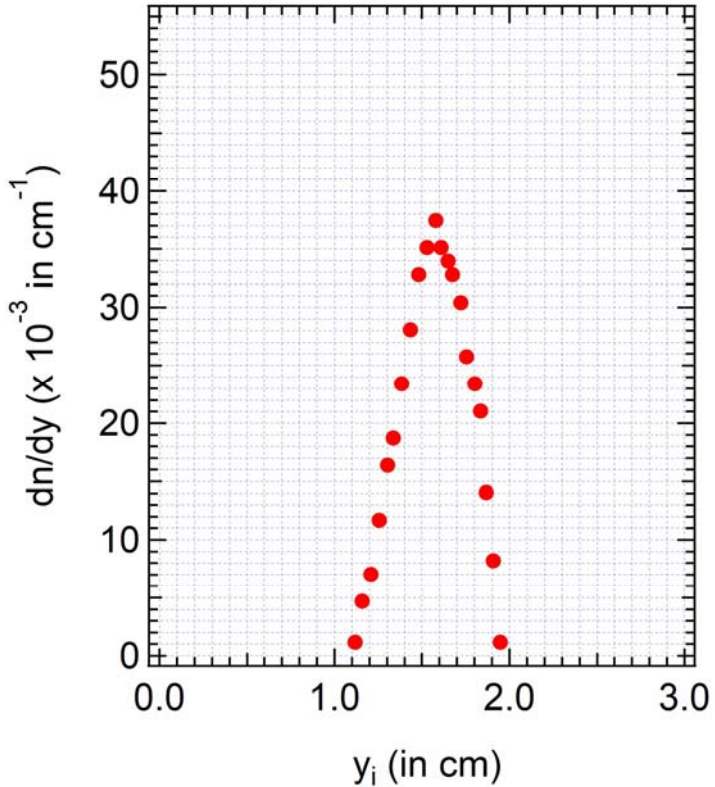
<p>A1.</p>	 <p>No dip</p> <p>No reference line</p> <p>Deflectogram (DL) not at the centre (+- 5mm) but the depth of dip still in 1.7 cm - 1.9 cm range</p> <p>DL at the centre, the depth of dip <1.7 cm or >1.9 cm</p> <p>DL not at the centre, the depth of dip <1.7 cm or >1.9 cm</p>	<p>of</p> <p>$C_0 = 28 \text{ gr}/150 \text{ mL}$</p> <p>Centred</p> <p>Deep of dip: 1.7 - 1.9 cm (0.4 pts)</p> <p>-0.4</p> <p>-0.05</p> <p>-0.05</p> <p>-0.05</p> <p>-0.1</p>
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<p>A1.</p>	 <p>No dip</p> <p>No reference line</p> <p>Deflectogram (DL) not at the centre (+5mm) but the depth of dip still in 1.9 - 2.3 cm range</p> <p>DL at the centre, the depth of dip <1.9 cm or >2.3 cm</p> <p>DL not at the centre, the depth of dip <1.9 cm or >2.3 cm</p>	<p>Deflectogram of</p> <p>$C_0 = 33 \text{ g}/150 \text{ mL}$</p> <p>Deep of dip: 1.9 - 2.3 cm</p> <p>(0.4 pts)</p> <p>-0.4 pts</p> <p>-0.05 pts</p> <p>- 0.05 pts</p> <p>- 0.05 pts</p> <p>-0.1</p>																																																																																																
<p>A2. (1.5 pts)</p>	<table border="1"> <thead> <tr> <th>i</th> <th>$\delta_i \text{ (cm)}$</th> <th>$\xi_i \text{ (cm)}$</th> <th>$Z_0 \text{ (cm)}$</th> <th>$d \text{ (cm)}$</th> <th>$Z \text{ (cm)}$</th> </tr> </thead> <tbody> <tr><td>1</td><td>0.05</td><td>11.55</td><td>10.4 ± 0.1</td><td>0.8 ± 0.1</td><td>53.4 ± 0.1</td></tr> <tr><td>2</td><td>0.35</td><td>11.3</td><td></td><td></td><td></td></tr> <tr><td>3</td><td>0.6</td><td>11.05</td><td></td><td></td><td></td></tr> <tr><td>4</td><td>0.9</td><td>10.85</td><td></td><td></td><td></td></tr> <tr><td>5</td><td>1</td><td>10.65</td><td></td><td></td><td></td></tr> <tr><td>6</td><td>1.1</td><td>10.35</td><td></td><td></td><td></td></tr> <tr><td>7</td><td>1.3</td><td>10.15</td><td></td><td></td><td></td></tr> <tr><td>8</td><td>1.4</td><td>9.85</td><td></td><td></td><td></td></tr> <tr><td>9</td><td>1.45</td><td>9.7</td><td></td><td></td><td></td></tr> <tr><td>10</td><td>1.5</td><td>9.45</td><td></td><td></td><td></td></tr> <tr><td>11</td><td>1.6</td><td>9.25</td><td></td><td></td><td></td></tr> <tr><td>12</td><td>1.5</td><td>8.95</td><td></td><td></td><td></td></tr> <tr><td>13</td><td>1.4</td><td>8.65</td><td></td><td></td><td></td></tr> <tr><td>14</td><td>1.2</td><td>8.35</td><td></td><td></td><td></td></tr> <tr><td>15</td><td>1</td><td>8.05</td><td></td><td></td><td></td></tr> </tbody> </table>	i	$\delta_i \text{ (cm)}$	$\xi_i \text{ (cm)}$	$Z_0 \text{ (cm)}$	$d \text{ (cm)}$	$Z \text{ (cm)}$	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				<p>Table 1 of</p> <p>$C_0 = 23 \text{ g}/150 \text{ mL}$</p> <p>Optimum Z and Z_0</p> <p># data = 20</p> <p>(0.5 pts)</p>
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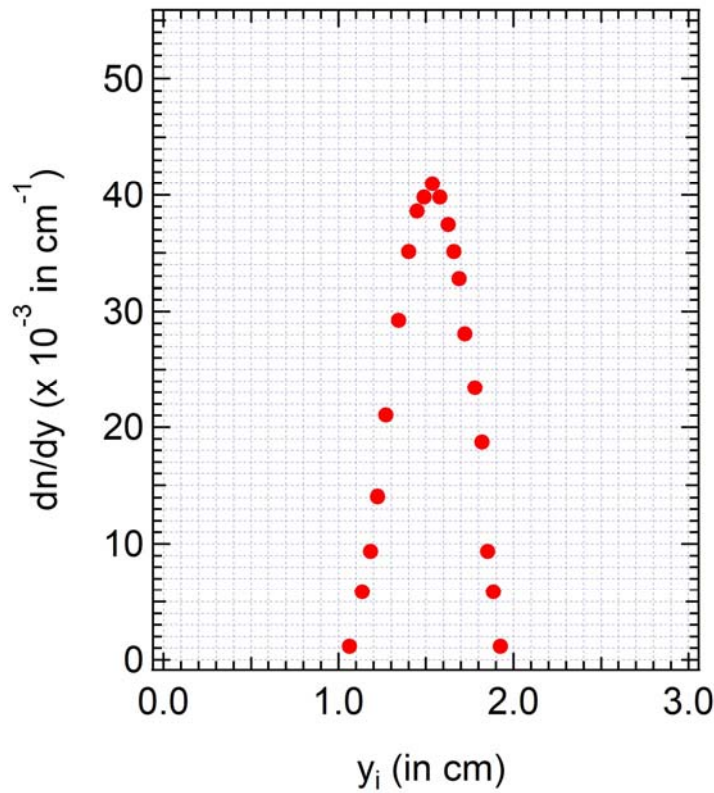
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<p>A3. (1.5 pts)</p>	<table border="1"> <thead> <tr> <th>i</th> <th>Y_i (cm)</th> <th>dn/dY</th> </tr> </thead> <tbody> <tr><td>1</td><td>1.85944</td><td>0.00117</td></tr> <tr><td>2</td><td>1.81919</td><td>0.00819</td></tr> <tr><td>3</td><td>1.77894</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> </tbody> </table> <p>Jury must check the data in table</p> <p># wrong data point < 3</p> <p>3<# wrong data point < 6</p> <p># wrong data point > 6</p>	i	Y _i (cm)	dn/dY	1	1.85944	0.00117	2	1.81919	0.00819	3	1.77894	0.01404	4	1.74674	0.02106	5	1.71455	0.02340	6	1.66625	0.02574	7	1.63405	0.03043	8	1.58575	0.03277	9	1.56161	0.03394	10	1.52136	0.03511	11	1.48916	0.03745	12	1.44086	0.03511	13	1.39257	0.03277	14	1.34427	0.02809	15	1.29597	0.02340	16	1.24767	0.01872	17	1.21548	0.01638	18	1.16718	0.01170	19	1.11888	0.00702	20	1.07058	0.00468	21	1.03034	0.00117	<p>Table 2 of</p> <p>C₀ = 23 g/150 mL.</p> <p># data = 20</p> <p>(0.25 pts)</p> <p>- 0</p> <p>- 0.05 pts</p> <p>- 0.25pts</p>
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<p>A3.</p>	<table border="1"> <thead> <tr> <th>i</th> <th>Y_i (cm)</th> <th>dn/dY</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>1.87554</td> <td>0.00117</td> </tr> <tr> <td>2</td> <td>1.83529</td> <td>0.00585</td> </tr> <tr> <td>3</td> <td>1.80309</td> <td>0.00936</td> </tr> <tr> <td>4</td> <td>1.77089</td> <td>0.01872</td> </tr> </tbody> </table>	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	<p>Table 2 of</p> <p>$C_0 = 28 \text{ g}/150 \text{ mL}$.</p> <p># data = 20</p>
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without x-axis label

without x-axis unit

wrong x-axis unit

without y-axis label

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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

A3.

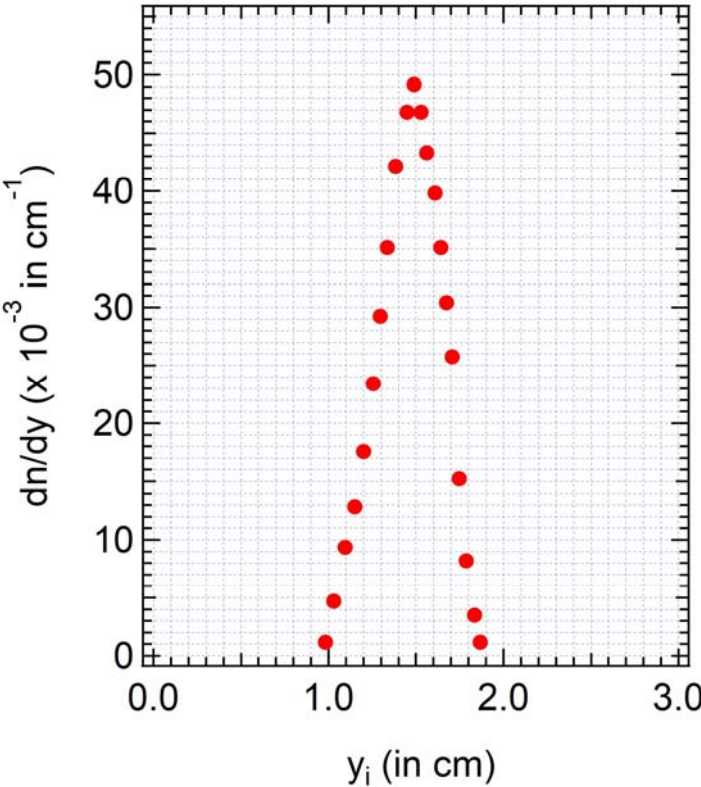
i	Y _i (cm)	dn/dY
1	1.86749	0.00117
2	1.83529	0.00351
3	1.78699	0.00819
4	1.74674	0.01521
5	1.70650	0.02574

Table 2 of

C₀ = 33 g/150 mL.

data = 20

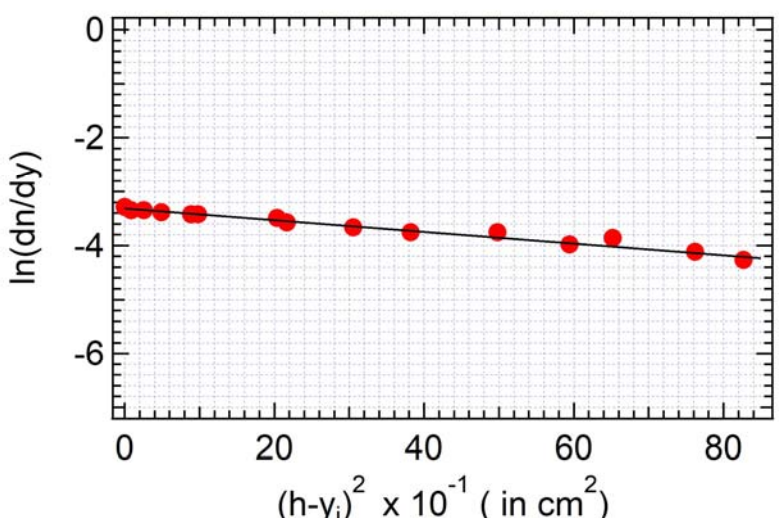
	<table border="1"> <tbody> <tr><td>6</td><td>1.67430</td><td>0.03043</td></tr> <tr><td>7</td><td>1.64210</td><td>0.03511</td></tr> <tr><td>8</td><td>1.60990</td><td>0.03979</td></tr> <tr><td>9</td><td>1.56161</td><td>0.04330</td></tr> <tr><td>10</td><td>1.52941</td><td>0.04681</td></tr> <tr><td>11</td><td>1.48916</td><td>0.04915</td></tr> <tr><td>12</td><td>1.44891</td><td>0.04681</td></tr> <tr><td>13</td><td>1.38452</td><td>0.04213</td></tr> <tr><td>14</td><td>1.33622</td><td>0.03511</td></tr> <tr><td>15</td><td>1.29597</td><td>0.02926</td></tr> <tr><td>16</td><td>1.25572</td><td>0.02340</td></tr> <tr><td>17</td><td>1.19938</td><td>0.01755</td></tr> <tr><td>18</td><td>1.15108</td><td>0.01287</td></tr> <tr><td>19</td><td>1.09473</td><td>0.00936</td></tr> <tr><td>20</td><td>1.03034</td><td>0.00468</td></tr> <tr><td>21</td><td>0.98204</td><td>0.00117</td></tr> </tbody> </table> <p>Jury must check the data in table</p> <p># wrong data point < 3</p> <p>3 < # wrong data point < 6</p> <p># wrong data point > 6</p>	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)
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<p>A4. (0.3 pts)</p>	<p>h for 23 g/ 150 mL = (1.5 ± 0.1) cm</p>	<p>0.1 pts</p>

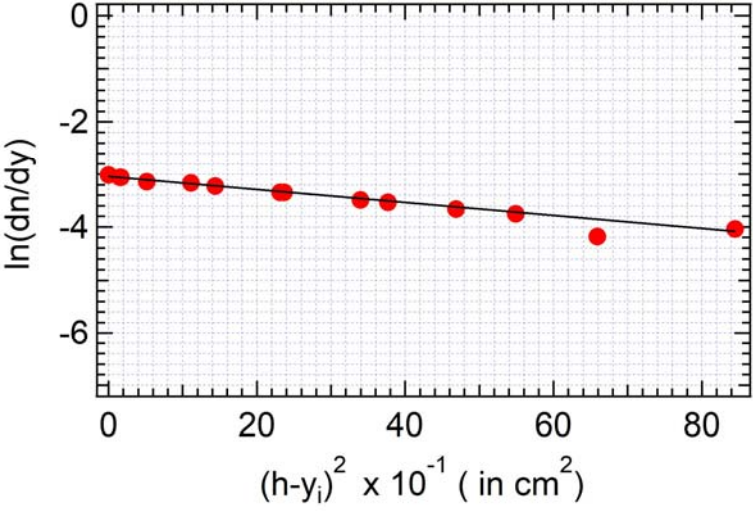
	h for 28 g/ 150 mL = (1.5 ± 0.1) cm	0.1 pts
	h for 33 g/ 150 mL = (1.5 ± 0.1) cm	0.1 pts
	If h is correctly determined from graph A3 for each concentration	- 0
	If h is not correctly determined from graph A3 for each concentration	-0.1

B : Determination of Diffusion Coefficient (4.2 points)

Question	Answer	Marks												
B1. (0.9 pts)	<p>Linear form of eq.(3)</p> $\ln\left(\frac{dn}{dy}\right) \approx m(h - Y)^2 + C \quad (b1)$ $m = -\frac{1}{4D_e t}$ <p>Constant : $C = \ln\left(\left(\frac{dn}{dc}\right)\left(\frac{c_0}{2\sqrt{\pi D_e t}}\right)\right)$</p> <p>Other than (b1)</p>	0.9 pt -0.9 pts												
B2. (1.8 pts)	<table border="1"> <thead> <tr> <th>i</th> <th>(h-yi)²</th> <th>ln(dn/dy)</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>0.06592</td> <td>-3.86003</td> </tr> <tr> <td>2</td> <td>0.050423</td> <td>-3.75467</td> </tr> <tr> <td>3</td> <td>0.031065</td> <td>-3.65936</td> </tr> </tbody> </table>	i	(h-yi) ²	ln(dn/dy)	1	0.06592	-3.86003	2	0.050423	-3.75467	3	0.031065	-3.65936	Table 3 of C ₀ = 23 g /150 mL.
i	(h-yi) ²	ln(dn/dy)												
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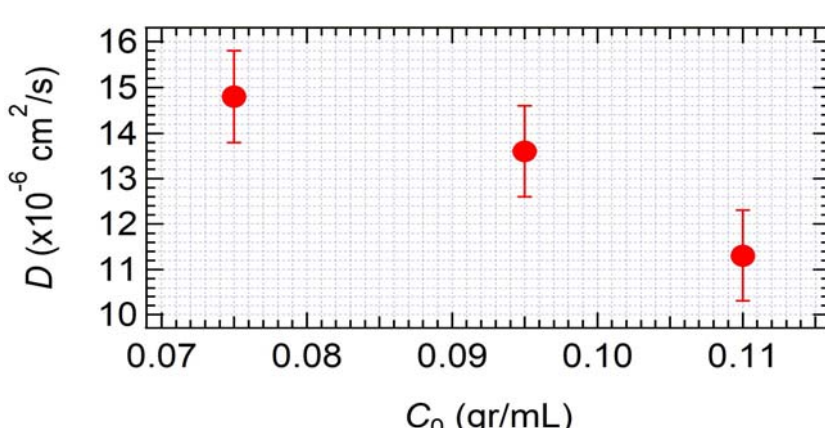
	<table border="1"> <tbody> <tr><td>4</td><td>0.020752</td><td>-3.4923</td></tr> <tr><td>5</td><td>0.00917</td><td>-3.41819</td></tr> <tr><td>6</td><td>0.005128</td><td>-3.3831</td></tr> <tr><td>7</td><td>0.000984</td><td>-3.3492</td></tr> <tr><td>8</td><td>6.99E-07</td><td>-3.28466</td></tr> <tr><td>9</td><td>0.002414</td><td>-3.3492</td></tr> <tr><td>10</td><td>0.009493</td><td>-3.41819</td></tr> <tr><td>11</td><td>0.021237</td><td>-3.57235</td></tr> <tr><td>12</td><td>0.037646</td><td>-3.75467</td></tr> <tr><td>13</td><td>0.05872</td><td>-3.97781</td></tr> </tbody> </table> <p>Jury must check the data in table</p> <p># of data point > 10</p> <p>3 <= # of data point < 10</p> <p># of data point < 3</p> <p># wrong data point < 3</p> <p>3 < # wrong data point < 6</p> <p># wrong data point > 6</p>	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	<p># data = 10</p> <p>(0.3 pts)</p> <p>-0 pts</p> <p>-0.05 pts</p> <p>-0.3 pts</p> <p>- 0</p> <p>- 0.05 pts</p> <p>- 0.25 pts</p>
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B2	 <p>Using linear regression of eq. (B1.1), we obtain</p> <p>m (slope) = -10 cm^{-2} till -8.8 cm^{-2}</p>	<p>Plot of Table 3</p> <p>$C_0 = 23 \text{ g}/150 \text{ mL}$</p> <p># data = 10</p> <p>(0.3pts)</p>																														

	<p># of data point in linear range > 10 -0.05 pts</p> <p>3 <= # of data point in linear range < 10 -0.3 pts</p> <p># of data point in linear range < 3 or random shape of curve -0.3 pts</p> <p>m is out of range</p>																																											
B2.	<table border="1"> <thead> <tr> <th>i</th> <th>(h-y_i)²</th> <th>ln(dn/dy)</th> </tr> </thead> <tbody> <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> </tbody> </table> <p>Jury must check the data in table</p> <p># of data point > 10 -0 pts</p> <p>3 <= # of data point < 10 -0.05 pts</p> <p># of data point < 3 -0.3 pts</p> <p># wrong data point < 3 - 0</p> <p>3<# wrong data point < 6 - 0.05 pts</p> <p># wrong data point >6 - 0.25</p>	i	(h-y _i) ²	ln(dn/dy)	1	0.046873	-3.65936	2	0.033968	-3.4923	3	0.023136	-3.3492	4	0.014378	-3.22404	5	0.005128	-3.13948	6	0.001553	-3.06152	7	6.99E-07	-3.01273	8	0.001688	-3.06152	9	0.011126	-3.16688	10	0.023647	-3.3492	11	0.037646	-3.53152	12	0.054884	-3.75467	13	0.08446	-4.04235	<p>Table 3 of C₀ = 33 g /150 mL</p> <p># data = 10</p> <p>(0.3 pts)</p>
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13	0.08446	-4.04235																																										
B2.		<p>Plot of Table 3</p> <p>C₀ = 33 g/150 mL</p>																																										

	 <p>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 $3 \leq$ # of data point in linear range < 10 # of data point in linear range < 3 or random shape of curve</p>	<p># 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</p>
<p>B3 (1.5 pts)</p>	<p>D of 23 g/ 150 mL = $(1.38 \text{ till } 1.58) \times 10^{-5} \text{ cm}^2/\text{s}$ D of 28 g/ 150 mL = $(1.26 \text{ till } 1.46) \times 10^{-5} \text{ cm}^2/\text{s}$</p>	<p>0.5 pts 0.5 pts</p>

	D of 33 g/ 150 mL = (1.03 till 1.23) $\times 10^{-5}$ cm ² /s D is out of range for each concentration	0.5 pts- -0.5 pts
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C. Nonlinear diffusion (1.3 points)

Question	Answer	Marks
C1. (1.3 pts)	 <p>Without error bars Value of C not stated in C₀/2</p>	Plot D vs. C_0 0.8 pts -0 -0.4 pts
C1.	$\frac{d}{dc}D = -4.2 \times 10^{-5} \text{ cm}^2 \text{ mL g}^{-1} \text{ s}^{-1}$ till $-15.8 \times 10^{-5} \text{ cm}^2 \text{ mL g}^{-1} \text{ s}^{-1}$	0.5 pts -0.01 pts -0.5 pts



E1. Marking Scheme & Solution

Student Code

Experimental
Question

1

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