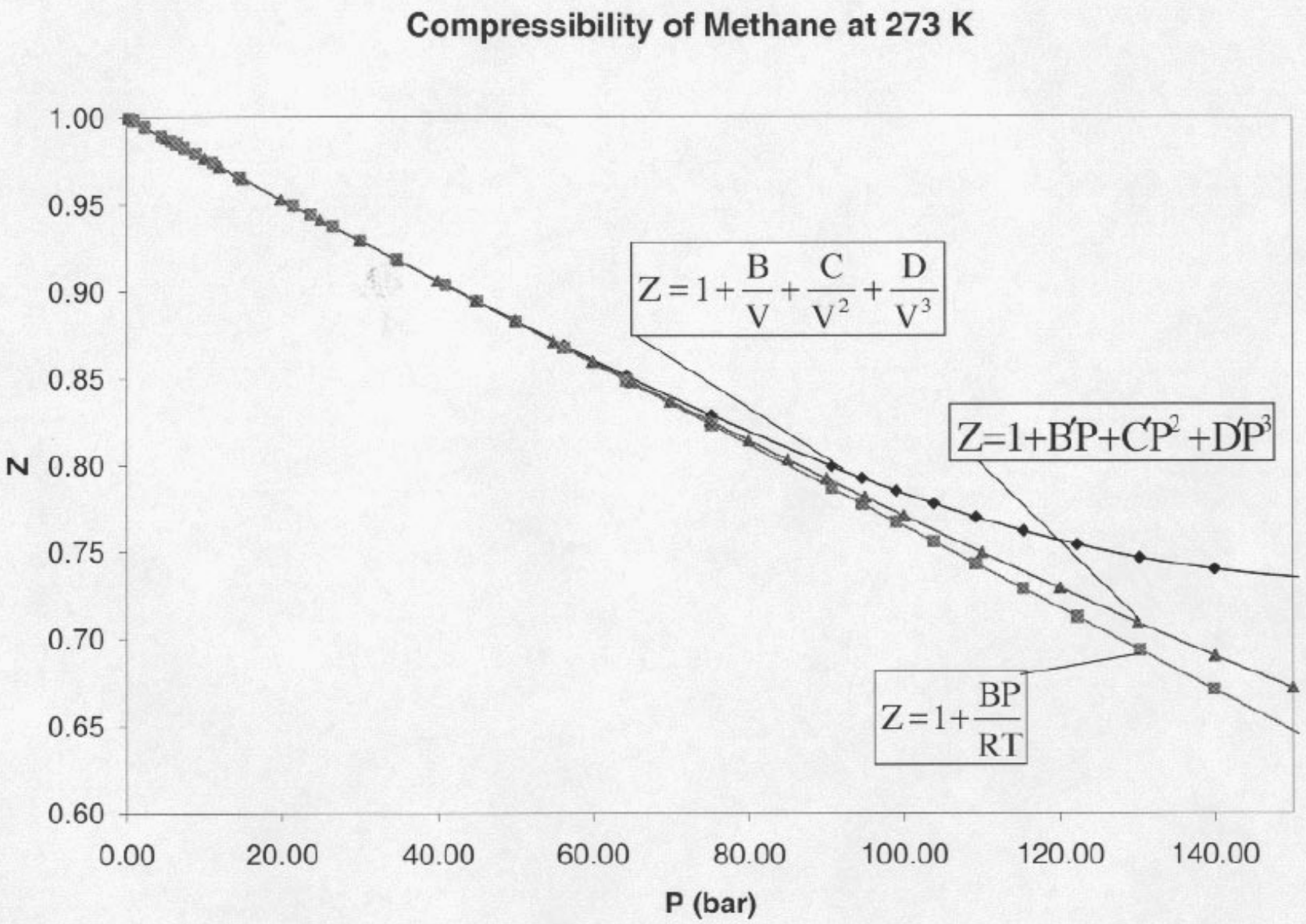
Compressibility of Methane at 273 K
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
N
0.00
20.00
40.00
60.00
80.00
100.00
120.00
140.00
P (bar)
$Z = 1 + \frac{B}{V} + \frac{C}{V^2} + \frac{D}{V^3}$
$Z = 1 + B'P + C'P^2 + D'P^3$
$Z = 1 + \frac{BP}{RT}$

Solution of Problem 4 **10.213**

The best way to approach this problem is to create a table of Z at different values of P and V, from which you can plot the required diagram. You can convert the virial equation constants given to the volume-explicit ones using S+VN p. 61. Then, you can use the volume-explicit equation to make a table of Z vs. P.

Another way is to use the equation given to calculate Z as a function of V. Then calculate P from the definition of Z. You should start from a low volume that gives a pressure higher than 150 bar.
Both methods are shown using a spreadsheet program to create the table and plot the chart.

The 2nd method is better because it avoids the use of the equations in page 61. These equations hold exactly only for the two virial expansions as infinite series. For the truncated forms of the virial equations, these relations are only approximate. This is the reason for the differences in the results.

B, cm^3/mol	C, cm^6/mol^2	D, cm^9/mol^3	T, K	R, $cm^3\ bar\ mol^{-1}\ K^{-1}$
-53.4	2620	5000	273	83.14

Method 1 using the relations of S+VN p. 61

B' = -0.00235271 **C' =** -4.4949E-07 **D' =** 1.0278E-08

P,bar	Z (4 terms) V-explicit	Z=1+BP/RT	%diff ideal from 4 term	%diff 2 term from 4 term	
0	1.00	1.00	0.0%	0.0%	Assuming 3% error is a
5	0.99	0.99	-1.2%	0.0%	good approximation
10	0.98	0.98	-2.4%	0.0%	
12	0.97	0.97	-2.9%	0.0%	ideal gas good
15	0.96	0.96	-3.7%	0.0%	up to **12 bar**
20	0.95	0.95	-4.9%	0.0%	
25	0.94	0.94	-6.3%	0.0%	
30	0.93	0.93	-7.6%	0.0%	
35	0.92	0.92	-9.0%	0.0%	
40	0.91	0.91	-10.4%	0.0%	
45	0.89	0.89	-11.8%	0.0%	
50	0.88	0.88	-13.3%	0.0%	
55	0.87	0.87	-14.8%	0.0%	
60	0.86	0.86	-16.4%	-0.1%	
65	0.85	0.85	-17.9%	-0.1%	
70	0.84	0.84	-19.5%	-0.2%	
75	0.83	0.82	-21.2%	-0.2%	
80	0.81	0.81	-22.8%	-0.3%	
85	0.80	0.80	-24.5%	-0.4%	
90	0.79	0.79	-26.2%	-0.5%	
95	0.78	0.78	-28.0%	-0.6%	
100	0.77	0.76	-29.8%	-0.8%	
110	0.75	0.74	-33.4%	-1.1%	
120	0.73	0.72	-37.2%	-1.5%	
130	0.71	0.69	-41.0%	-2.1%	
140	0.69	0.67	-44.9%	-2.8%	2 terms good
150	0.67	0.65	-48.9%	-3.7%	up to **140 bar**

Method 2

V, cm^3/mol	Z (4 terms) P-explicit	P, bar = ZRT/V	Z=1+BP/RT	% diff. Ideal from 4 term	% diff 2 term from 4 term	
100	0.73	166.37	0.61	-36.4%	17.0%	
110	0.73	151.62	0.64	-36.1%	12.5%	
120	0.74	139.94	0.67	-35.2%	9.3%	
130	0.75	130.34	0.69	-34.0%	7.1%	
140	0.75	122.25	0.71	-32.6%	5.5%	
150	0.76	115.29	0.73	-31.2%	4.4%	
160	0.77	109.20	0.74	-29.9%	3.5%	2 terms good up
170	0.78	103.81	0.76	-28.6%	2.8%	to **104 bar**
180	0.79	98.99	0.77	-27.4%	2.3%	
190	0.79	94.64	0.78	-26.2%	1.9%	
200	0.80	90.69	0.79	-25.1%	1.6%	
250	0.83	75.23	0.82	-20.7%	0.7%	
300	0.85	64.41	0.85	-17.5%	0.3%	
350	0.87	56.35	0.87	-15.1%	0.2%	
400	0.88	50.10	0.88	-13.3%	0.1%	
450	0.89	45.11	0.89	-11.8%	0.1%	
500	0.90	41.02	0.90	-10.7%	0.0%	
600	0.92	34.74	0.92	-8.9%	0.0%	
700	0.93	30.12	0.93	-7.6%	0.0%	
800	0.94	26.59	0.94	-6.7%	0.0%	
900	0.94	23.80	0.94	-5.9%	0.0%	
1000	0.95	21.54	0.95	-5.3%	0.0%	
1500	0.97	14.61	0.97	-3.6%	0.0%	ideal gas law is
2000	0.97	11.05	0.97	-2.7%	0.0%	a good approx. to
2500	0.98	8.89	0.98	-2.1%	0.0%	**11.1 bar**
3000	0.98	7.43	0.98	-1.8%	0.0%	
3500	0.98	6.39	0.98	-1.5%	0.0%	
4000	0.99	5.60	0.99	-1.3%	0.0%	
5000	0.99	4.49	0.99	-1.1%	0.0%	
10000	0.99	2.26	0.99	-0.5%	0.0%	
30000	1.00	0.76	1.00	-0.2%	0.0%	
100000	1.00	0.23	1.00	-0.1%	0.0%	