Assigned problems for Lecture 1 are listed below (corrections and updates are highlighted in yellow). The questions occur in the following editions of “Physical Chemistry” by P.W. Atkins:

|--------------|--------------|-------------|-------------|

An entry of n/a indicates that the question has been discontinued (answers to these are at the end of the assignment).

**Question 1.01**

<table>
<thead>
<tr>
<th>n/a</th>
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</thead>
</table>

*These are problems from the 7th edition (1.4) that was discontinued from the 8th edition onwards.*

(a) A sample of air occupies 1.0 L at 25 °C and 1.00 atm. What pressure is needed to compress it to 100 cm³ at this temperature?
(b) A sample of carbon dioxide gas occupies 2.0 dm³ at 20 °C and 104 kPa. What pressure is needed to compress it to 250 cm³ at this temperature?

**Question 1.02**

<table>
<thead>
<tr>
<th>1A.3</th>
<th>1A.2</th>
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<th>1.2</th>
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</table>

1A.2(a) A perfect gas undergoes isothermal compression, which reduces its volume by 2.20 dm³. The final pressure and volume of the gas are 5.04 bar and 4.65 dm³, respectively. Calculate the original pressure of the gas in (i) bar, (ii) atm.

1A.2(b) A perfect gas undergoes isothermal compression, which reduces its volume by 1.80 dm³. The final pressure and volume of the gas are 1.97 bar and 2.14 dm³, respectively. Calculate the original pressure of the gas in (i) bar, (ii) torr.

**Question 1.03**

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</table>

*These are problems from the 7th edition (1.7) that was discontinued from the 8th edition onwards.*

(a) To what temperature must a 1.0 L sample of a perfect gas be cooled from 25 °C in order to reduce its volume to 100 cm³?
(b) To what temperature must a sample of a perfect gas of volume 500 mL be cooled from 35 °C in order to reduce its volume to 150 cm³?

**Question 1.04**

<table>
<thead>
<tr>
<th>1A.5</th>
<th>1A.4</th>
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</table>

1A.4(a) A sample of 255 mg of neon occupies 3.00 dm³ at 122 K. Use the perfect gas law to calculate the pressure of the gas.

1A.4(b) A homeowner uses $4.00 \times 10^3$ m³ of natural gas in a year to heat a home. Assume that natural gas is all methane, CH₄, and that methane is a perfect gas for the conditions of this problem, which are 1.00 atm and 20 °C. What is the mass of gas used?
Question 1.05

P1A.1(ii); P1A.4

In an attempt to determine an accurate value of the gas constant, \( R \), a student heated a container of volume 20.000 dm\(^3\) filled with 0.251 32 g of helium gas to 500 °C and measured the pressure as 206.402 cm of water in a manometer at 25 °C. Calculate the value of \( R \) from these data. (The density of water at 25 °C is 0.997 07 g cm\(^{-3}\); the construction of a manometer is described in Exercise 1.6(a).)

P1A.4 The following data have been obtained for oxygen gas at 273.15 K. The density of oxygen at 273.15 K is 0.001344 g cm\(^{-3}\). Calculate the best value of the gas constant \( R \) from them and the best value of the molar mass of O\(_2\).

<table>
<thead>
<tr>
<th>( \frac{p}{\text{atm}} )</th>
<th>0.750 000</th>
<th>0.500 000</th>
<th>0.250 000</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \frac{V_m}{(\text{dm}^3\text{mol}^{-1})} )</td>
<td>29.9649</td>
<td>44.8090</td>
<td>89.6384</td>
</tr>
</tbody>
</table>

Clarifications:

Question 1.05

The molar volume is given incorrectly in the first column, it should be 29.8649 not 29.9649. I did the problems from the 6th edition (where this is correct) and for some reason, this mistake has not been noticed in the 7th to 10th editions - but it has been fixed for the 11th edition (finally!)

A-list solutions for 1.01 and 1.03

**E1.4(a)**

Boyle’s law \([1.6]\) provides the basis for the solution.

Since \( pV = \text{constant} \), \( p_fV_f = p_iV_i \)

Solving for \( p_f \), \( p_f = \frac{V_i}{V_f} \times p_i \)

\( V_i = 1.0 \text{ L} = 1000 \text{ cm}^3 \), \( V_f = 100 \text{ cm}^3 \), \( p_i = 1.00 \text{ atm} \)

\[ p_f = \frac{1000 \text{ cm}^3}{100 \text{ cm}^3} \times 1.00 \text{ atm} = 10 \times 1.00 \text{ atm} = \underline{10 \text{ atm}} \]

**E1.7(a)**

Charles’s law in the form \( V = \text{constant} \times T \) \([1.9]\) may be rewritten as \( \frac{V}{T} = \text{constant} \) or \( \frac{V_f}{T_f} = \frac{V_i}{T_i} \)

Solving for \( T_f \), \( T_f = \frac{V_f}{V_i} \times T_i \), \( V_i = 1.0 \text{ L} \), \( V_f = 100 \text{ cm}^3 \), \( T_i = 298 \text{ K} \)

\[ T_f = \left( \frac{100 \text{ cm}^3}{1000 \text{ cm}^3} \right) \times (298 \text{ K}) = \underline{30 \text{ K}} \]
B-list solutions for 1.01 and 1.03

**E1.4(b)**  Boyle’s law applies.

\[ pV = \text{constant} \quad \text{so} \quad p_f V_f = p_i V_i \]

\[ p_f = \frac{p_i V_i}{V_f} = \frac{(104 \text{ kPa}) \times (2000 \text{ cm}^3)}{(250 \text{ cm}^3)} = 832 \text{ kPa} \]

**E1.7(b)**  Charles’s law applies.

\[ V \propto T \quad \text{so} \quad \frac{V_i}{T_i} = \frac{V_f}{T_f} \]

and \[ \frac{T_f}{V_i} = \frac{(150 \text{ cm}^3) \times (35 + 273) \text{ K}}{500 \text{ cm}^3} = 92.4 \text{ K} \]