

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:

10th edition	9th edition	8th edition
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**Question 1.01**

n/a	n/a	n/a
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*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 cm<sup>3</sup> at this temperature?
- (b) A sample of carbon dioxide gas occupies 2.0 dm<sup>3</sup> at 20 °C and 104 kPa. What pressure is needed to compress it to 250 cm<sup>3</sup> at this temperature?

**Question 1.02**

1A.2	1.2	1.2
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**1A.2(a)** A perfect gas undergoes isothermal compression, which reduces its volume by 2.20 dm<sup>3</sup>. The final pressure and volume of the gas are 5.04 bar and 4.65 dm<sup>3</sup>, 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 dm<sup>3</sup>. The final pressure and volume of the gas are 1.97 bar and 2.14 dm<sup>3</sup>, respectively. Calculate the original pressure of the gas in (i) bar, (ii) torr.

**Question 1.03**

n/a	n/a	n/a
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*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 cm<sup>3</sup>?
- (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 cm<sup>3</sup>?

**Question 1.04**

1A.4	1.4	1.4
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**1A.4(a)** A sample of 255 mg of neon occupies 3.00 dm<sup>3</sup> at 122 K. Use the perfect gas law to calculate the pressure of the gas.

**1A.4(b)** A homeowner uses  $4.00 \times 10^3$  m<sup>3</sup> of natural gas in a year to heat a home. Assume that natural gas is all methane, CH<sub>4</sub>, 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

1A.7	1.7	1.7
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**1A.7(a)** In an attempt to determine an accurate value of the gas constant,  $R$ , a student heated a container of volume 20.000 dm<sup>3</sup> 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<sup>-3</sup>; the construction of a manometer is described in Exercise 1.6(a).)

**1A.7(b)** 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<sup>-3</sup>. Calculate the best value of the gas constant  $R$  from them and the best value of the molar mass of O<sub>2</sub>.

$p/\text{atm}$	0.750 000	0.500 000	0.250 000
$V_m/(\text{dm}^3 \text{mol}^{-1})$	29.9649	44.8090	89.6384

## Clarifications:

## Question 1.05

1A.7	1.7	1.7
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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.

## A-list solutions for 1.01 and 1.04

**E1.4(a)** Boyle's law [1.6] provides the basis for the solution.

Since  $pV = \text{constant}$ ,  $p_f V_f = p_i V_i$

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

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

$$p_f = \frac{1000 \text{ cm}^3}{100 \text{ cm}^3} \times 1.00 \text{ atm} = 10 \times 1.00 \text{ atm} = \boxed{10 \text{ atm}}$$

**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  $T_f$ ,  $T_f = \frac{V_f}{V_i} \times T_i$ ,  $V_i = 1.0 \text{ L}$ ,  $V_f = 100 \text{ cm}^3$ ,  $T_i = 298 \text{ K}$

$$T_f = \left( \frac{100 \text{ cm}^3}{1000 \text{ cm}^3} \right) \times (298 \text{ K}) = \boxed{30 \text{ K}}$$

## B-list solutions for 1.01 and 1.04

**E1.4(b)** Boyle's law applies.

$$pV = \text{constant} \quad \text{so} \quad p_f V_f = p_i V_i$$
$$p_f = \frac{p_i V_i}{V_f} = \frac{(104 \text{ kPa}) \times (2000 \text{ cm}^3)}{(250 \text{ cm}^3)} = \boxed{832 \text{ kPa}}$$

**E1.7(b)** Charles's law applies.

$$V \propto T \quad \text{so} \quad \frac{V_i}{T_i} = \frac{V_f}{T_f}$$
$$\text{and } T_f = \frac{V_f T_i}{V_i} = \frac{(150 \text{ cm}^3) \times (35 + 273) \text{ K}}{500 \text{ cm}^3} = \boxed{92.4 \text{ K}}$$