1. Consider a system where gas is confined to a subvolume $V_1$ in an insulated rigid container. The container has an adjoining subvolume $V_2$, initially evacuated, connected to $V_1$ by opening a valve ($V_1 = V_2$). When the valve is opened, gas fills the entire volume, $V_1 + V_2$.

If the amount of heat exchanged with the environment is negligible during the expansion, what type of process is the expansion?

**Adiabatic Expansion**

Is the first chamber (subvolume $V_1$) a closed system?

**Once the valve is opened the system is no longer closed**

If $V_1$ is not a closed system, then what system is?

**Open**

2. Identify each of the following variables as either extensive or intensive

<table>
<thead>
<tr>
<th>Variable</th>
<th>intensive</th>
<th>extensive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Pressure</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Volume</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Density</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Specific volume</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td># of moles</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>salinity</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>
3. Units (check your equations to make sure that the units on both sides of the equal sign match!). The ideal gas law assumes that the gas molecules are infinitely small and that there are no intermolecular interactions. Real gases, particularly under conditions of high pressure, do not satisfy these conditions. Numerous different forms of the equation of state for real gases have been formulated. The van der Waals equation of state is a semi-empirical relation and is written as

\[(p + \frac{an^2}{V^2})(V - nb) = nR^*T\]

where \(p\) is pressure, \(V\) is volume, \(T\) is temperature, and \(R^*\) is the universal gas constant. Find the dimensions of the constants \(a\) and \(b\) and express these dimensions in SI units.

Units: To add or subtract the units must be the same so

- \(p\) - N/m\(^2\) or Pa
- \(V\) - m\(^3\)
- \(T\) - K
- \(n\) - mol
- \(R^*\) - J/mol/K
- \(J\) - Nm

4. Molecular weight and mole fractions:

<table>
<thead>
<tr>
<th>Element</th>
<th>Molecular weight (g mole(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen</td>
<td>1</td>
</tr>
<tr>
<td>Oxygen</td>
<td>16</td>
</tr>
<tr>
<td>Sodium</td>
<td>23</td>
</tr>
<tr>
<td>Chlorine</td>
<td>35</td>
</tr>
</tbody>
</table>

a) Calculate the molecular weight of H\(_2\)O

\[1 \times 2 + 16 = 18 \text{ g/mol}\]

b) Calculate the molecular weight of NaCl

\[23 + 35 = 58 \text{ g/mol}\]

c) A water solution has salt concentration of 3.5% by mass. What is the mole fraction of this solution, where the mole fraction is the ratio of the number of moles of salt to the total number of moles (water + salt)?

\[
\frac{\text{mol NaCl}}{\text{mol NaCl} + \text{mol H}_2\text{O}} = \frac{3.5}{58} = \frac{96.5}{58 + 18} = 1.113%\]

5. Which two gases are most abundant in the atmosphere?

Nitrogen and Oxygen

6. Which atmospheric gas(es) can condense under normal atmospheric conditions?

Water Vapor (H\(_2\)O)

7. What is a typical salinity of the ocean?

34.7psu (practical salinity units)

8. List at least 3 processes that modify the surface salinity of the ocean:

Evaporation  Precipitation  River Runoff  Glacier Melt
9. Using the data listed in Table 1.2, consider the following questions:
   a) In seawater, the proportion by weight of negative ions greatly exceeds that of positive ions. Why does seawater not carry a net negative charge? Even though the table suggests that by ‘weight’ negative ions greatly exceed positive ions, if you consider it by mol, you achieve a different balance.
   b) What is the ratio of potassium concentration to total salinity? What would the potassium concentration be if the salinity rose to 36 psu? If it fell to 33 psu?

\[
\begin{array}{lll}
0.380 \text{ K} & 0.380 \text{ K} & 0.380 \text{ K} \\
34.482 \text{ Total} & 36 \text{ Total} & 33 \text{ Total} \\
\end{array}
\]

0.380 K or 1.1% 0.380 K or 1.06% 0.380 K or 1.15%

10. Match the atmospheric particle to a representative size (note you can you use the same size more than once) (NOTE: info not in chapter 1, use logic!)

- _____e_____ Raindrop  a. 0.1 \(\mu\)m
- _____d______ Ice crystal  b. 1 \(\mu\)m
- _____a______ Aerosol particle  c. 10 \(\mu\)m
- _____c______ Cloud drop  d. 100 \(\mu\)m
- _____f______ Snow flake  e. 1 mm
-  f. 1 cm
g. 1 m

Planetary Atmospheres

11. Rank the following planets in order of increasing planetary mass (1 for lowest mass)

___1___ Mercury
___3___ Venus
___4___ Earth
___2___ Mars

12. Rank the following planets in order of increasing atmospheric surface pressure (1 for lowest pressure)

___1___ Mercury
___4___ Venus
___3___ Earth
___2___ Mars

13. Why is the atmospheric pressure on Venus so much greater than that on Earth?
   Its atmosphere is thicker and denser due to high temperatures allowing more vapor existence of elements.

14. Why does Mercury barely have an atmosphere?
   Mercury’s high temperature and low gravitational field allow for high escape velocities of gases from the planet.
15. Why is the composition of the Jovian planets (e.g. Jupiter, Saturn) so different from the inner terrestrial planets?

   The development of the Jovian planets occurred as ‘failed’ stars, whereas the inner planets came about from the concentration of heavier elements during solar system development.

16. Why is the composition of the Martian atmosphere different from the Earth’s atmosphere?

   The difference is primarily driven by the fact that Mars lacks a magnetic field.