1. Norsk: Under hvilke omstendigheter vil du forvente at en gass skal oppføre seg betydelig annerledes enn det som er gitt ut fra ideell gasslov? Gi en begrunnelse for svaret ditt.

   English: Under what circumstances would you expect a gas to behave significantly differently from that given by the ideal gas law? Give a reason for your answer.

   Fasit:
   The ideal gas law has some assumptions about the gas molecules and forces between them.
   a) The distance between molecules is small compared to the size of the molecules
   b) The molecules interact by elastic collisions (just bounce off each other)

   A gas will not follow the ideal gas law if these conditions aren't met.

   a) The density of the gas is very high, high temperature, high pressure
   b) The gas molecules have strong interactions, ie water vapor.

2. Norsk: Måletrykket i bildekk er $2{,}50\times10^5 N/m^2$ ved en temperatur på 35,0°C når du kjører den på en ferge til Finnmark. Hva er det målet dekktrykk senere, når temperaturen har falt til -40,0°C?

   English: The measured pressure in a car tire is 2.50×10^5 N/m^2 at a temperature of 35.0°C when you drive it on a ferry to Finnmark. What is the measured tire pressure later, when the temperature has dropped to -40.0°C?

   Fasit:

   Car tire at T_0 = 35.0 °C , and pressure $P_0 = 2.5 \text{ X } 10^5$ N/m^2
   Pressure at T_f = - 40.0 °C, P_f = ?

   Use PV = N k T, This formula is for T in Kelvin

   T_0 = 35.0 °C = 308 K
   T_f = - 40.0 °C = 233 K

$$\frac{P_0 V = N\,k\,T_0}{P_f V = N\,k\,T_f} \Longrightarrow \frac{P_0}{P_f} = \frac{T_0}{T_f}$$

$$P_f = P_0\,\frac{T_f}{T_0} = 2.5 \times 10^5\,N/m^2 \cdot \frac{233\,K}{308\,K}$$

$$P_f = 1.9 \times 10^5\,N/m^2$$

3. Norsk: Et dyrt vakuumsystem kan oppnå et trykk så lavt som $1{,}00\times10^{-7}$ N/m^2 ved 20°C. Hvor mange atomer er det i en kubikkcentimeter ved dette trykket og temperaturen?

   English: An expensive vacuum system can achieve a pressure as low as 1.00×10^{-7} N/m^2 at 20°C. How many atoms are there in a cubic centimeter at this pressure and temperature?

   Fasit:
   P = 1.00×10^{-7} N/m^2
   T = 20°C = 293 K
   V = 1.0 cm^3 = 10^{-6} m^3

   Use PV = N k T to find molecules in 1 cubic centimeter

$$N = \frac{P\,V}{k\,T} = \frac{1.00\ \times 10^{-7}\ {}^{N}/_{m^2} \cdot 1.00\ \times 10^{-6}\ m^3}{1.38\ \times 10^{-23}\ {}^{J}/_{K} \cdot 293\ K} = 2.47 \times 10^{7}\ molecules$$

4. Norsk:
   a) Hva er den gjennomsnittlige kinetiske energien til et gassmolekyl ved T = 25°C?
   b) Hva er rms-hastigheten for et nitrogenmolekyl N_2 med denne kinetiske energien?
   c) Hva er rms-hastigheten for et heliumatom He med denne kinetiske energien?

   English:
   a) What is the average kinetic energy of a molecule of gas at T = 25°C ?
   b) What is the rms speed for a Nitrogen molecule N_2 with this average kinetic energy?
   c) What is the rms speed for a Helium atom He with this average kinetic energy?

   Fasit:
   a) Average kinetic energy:
   $\overline{KE} = \frac{3}{2}\, kT$

   Boltzmann constant: k = $1.38 \cdot 10^{-23}$ J/K

   T = 25°C = (273.15 + 25) K = 298.15 K

   $\overline{KE} = \frac{3}{2}\, kT$ = 3/2 ($1.38 \cdot 10^{-23}$ J/K) · 298.15 K = 6.17×10^{-21} J

   b) The rms velocity can be found using

$$\overline{KE} = \frac{1}{2}\, m\overline{v^2}$$

   Solve for $\overline{v^2}$

$$\overline{v^2} = \frac{2}{m}\,\overline{KE}$$

$$v_{rms} = \sqrt{\overline{v^2}} = \sqrt{\frac{2}{m}\,\overline{KE}}$$

   The mass of a nitrogen molecule m_N = molar mass / avogadros constant

Molar mass of N_2 = 28.01 g/mol, $N_A = 6.023 \cdot 10^{23}\ mol^{-1}$

$m_N = 28.01\ (g/mol) / 6.023 \cdot 10^{23}\ mol^{-1} = 4.65 \cdot 10^{-23}\ g = 4.65 \cdot 10^{-26}\ kg$

the rms velocity is:

$$v_{rms} = \sqrt{\frac{2}{4.65\ \cdot\ 10^{-26}\ \mathrm{kg}} 6.17 \cdot 10^{-21}\ \mathrm{J}} = 515\ m/s$$

c) The mass of a helium atom m_H = molar mass / avogadros constant

Molar mass of He = 4.003 g/mol

$m_H = 4.003\ (g/mol) / 6.023 \cdot 10^{23}\ mol^{-1} = 6.65 \cdot 10^{-24}\ g = 6.65 \cdot 10^{-27}\ kg$

the rms velocity is:

$$v_{rms} = \sqrt{\frac{2}{6.65\ \cdot\ 10^{-27}\ \mathrm{kg}} 6.17 \cdot 10^{-21}\ \mathrm{J}} = 1362\ m/s$$