Thermal expansion questions

1. Hva betyr det at to systemer er i termisk likevekt?

   They are in thermal contact and can exchange heat. The two systems are in thermal equilibrium when they have exchanged heat until they reach the same temperature.

2. Termiske belastninger forårsaket av ujevn kjøling kan lett bryte glasskokekar. Forklar hvorfor Pyrex®, et glass med en liten koeffisient av lineær ekspansjon, er mindre utsatt.

   The uneven cooling causes varying thermal expansion across the glass. Expansion in only one part of the glass creates a stress that can break the glass. Pyrex® glass expands less with temperature and therefore the stresses caused by temperature differences is less.

3. Hjelper det virkelig å kjøre varmt vann over et tett metall lokk på et glass før du prøver å åpne den? Forklar svaret ditt.

   Yes. The metal lid will expand as it warms and will not be as tight on the glass jar.

4. Eiffel tower has height h = 321 m at temperature T
   The temperature increases by ΔT = 15 °C
   Expansion coefficient of steel $\alpha_s = 12 \text{ X } 10^{-6}$ 1/C

$$\Delta L = \alpha\, L\, \Delta T = 12 \times 10^{-6} \frac{1}{C}\, 321\, m \cdot 15\, C = 5.8 \times 10^{-2}\, m = 58\, cm$$

5. The steel train tracks have a length L = 10.0 m. The maximum temperature change expected is ΔT = 35.0 °C
   The thermal expansion of the track will be

$$\Delta L = \alpha\, L\, \Delta T = 12 \times 10^{-6} \frac{1}{C}\, 10.0\, m \cdot 35.0\, C = 4.2 \times 10^{-3}\, m = 0.42\, cm$$

6. We have two measuring bands, one of steel and one of invar at T = 0 °C
   Expansion coefficient of steel $\alpha_s = 12 \text{ X } 10^{-6}$ 1/C
   And the expansion coefficient of Invar is $\alpha_I = 0.9 \text{ X } 10^{-6}$ 1/C
   At T = 22 °C both will expand

   a) The difference between the 1 meter sticks after expansion:

$$\Delta L_s = \alpha_s\, L\, \Delta T = 12 \times 10^{-6} \frac{1}{C}\, 1.0\, m \cdot 22.0\, C = 2.64 \times 10^{-4}\, m$$

$$\Delta L_I = \alpha_I\, L\, \Delta T = 0.9 \times 10^{-6} \frac{1}{C}\, 1.0\, m \cdot 22.0\, C = 0.198 \times 10^{-4}\, m$$

   The difference between the 1 meter sticks after expansion:

$$\Delta L = \Delta L_s - \Delta L_I = 2.44\; 10^{-4}\, m$$

   b) The difference for 30 meter bands is

$$(\Delta L_s - \Delta L_I) = (\alpha_s - \alpha_I)\; L\, \Delta T = (12.0 - 0.9)\times 10^{-6} \frac{1}{C}\, 30.0\, m \cdot 22.0\, C$$
$$= 7.3 \times 10^{-3}\, m$$

Ideal gas questions

7. 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.

8. Ideal gas follows the equation PV = n k T
   If you hold volume constant, the pressure will change with changing temperature.

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

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

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

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

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

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

10. Vacuum system:
    $P = 1.00 \times 10^{-7}\ N/m^2$
    $T = 20°C = 293\ K$
    $V = 1.0\ cm^3 = 10^{-6}\ m^3$

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

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

11. Ideal gas:
    $P = 7.41 \times 10^7\ N/m^2$
    $T = 35°C = 308\ K$
    $V = 2.00\ l = 2.00 \times 10^{-3}\ m^3$

    Here we use PV = n RT to get number of moles

$$n = \frac{P\,V}{R\,T} = \frac{7.41\ \times 10^{7}\ {}^{N}\!/_{m^2} \cdot 2.00\ \times 10^{-3}\ m^3}{8.31\ \ {}^{J}\!/_{(mol\cdot K)} \cdot 308\ K} = 58\ mol$$