1. The faster atoms and molecules of the warmer water are colliding with the particles of the thermometer tube, which makes them wiggle more. The increase in movement of the atoms and molecules of the glass tube results in a more intense movement of the particles of the thermometer liquid. The thermometer liquid expands and rises up the tube. The temperature can be read on a scale on the tube.

2. a) - 273.15 °C or 0 K

   b) When an object cools down, the movement of its atoms and molecules becomes less. The temperature, at which the particles stop moving, is the lowest possible temperature and it is called absolute zero.

3. a) 56.7 °C – (– 89.2 °C) = 56.7 K + 89.2 K = <u>145.9 K</u>

   b) 56.7 °C + 273.15 = <u>329.9 K</u> – 89.2 °C + 273.15 = <u>184.0 K</u>

4. a) Porcelain expands **four** times as much as cork.

   b) Zinc expands twice as much as **steel**.

5. a) ① down, ② up. The material with a larger coefficient of linear expansion contracts more.

   b) ②. The difference in the coefficient of linear expansion of the two substances is greater.

6. a) $\Delta\ell = \alpha \cdot \ell_0 \cdot \Delta T = 12 \cdot 10^{-6} \frac{1}{K} \cdot 324.0\text{ m} \cdot 50.0\text{ K} =$ <u>0.194 m</u> = <u>19 cm</u>

   b) $\ell = \ell_0 + \Delta\ell = 324.0\text{ m} + 0.19\text{ m} =$ <u>324.2 m</u>

7. $\Delta\ell = \alpha \cdot \ell_0 \cdot \Delta T = 14 \cdot 10^{-6} \frac{1}{K} \cdot 200.00\text{ mm} \cdot 20.000\text{ K} = 0.056\text{ mm}$

   $\ell = \ell_0 - \Delta\ell = 200.00\text{ mm} - 0.056\text{ mm} =$ <u>199.94 mm</u>

8. $$\Delta T = \frac{\Delta\ell}{\alpha \cdot \ell_0} = \frac{1.0\text{ mm}}{23.8 \cdot 10^{-6}\frac{1}{K} \cdot 1000.0\text{ mm}} = 42\text{ K}$$

   $\vartheta = \vartheta_0 + \Delta T = 15\text{ °C} + 42\text{ K} =$ <u>57 °C</u>

9. $$\alpha = \frac{\Delta\ell}{\ell_0 \cdot \Delta T} = \frac{0.70\text{ mm}}{1000.0\text{ mm} \cdot 50.0\text{ K}} = 0.000014\ \frac{1}{K} = 14 \cdot 10^{-6}\ \frac{1}{K} \Rightarrow$$ <u>gold</u>

10.

change in volume of:	„normal“ liquid	water
when the temperature decreases from 4 °C to 0 °C	contracts	expands
when ice water freezes to become solid ice	contracts	expands by 10 %

11. If the water freezes, the tubes could burst.

12. a) $\Delta V = \gamma \cdot V_0 \cdot \Delta T = 1.10 \cdot 10^{-3} \frac{1}{K} \cdot 0.500\ \ell \cdot 30.0\ K = \underline{0.0165\ \ell} = \underline{16.5\ m\ell}$

    b) $V = V_0 + \Delta V = 0.500\ \ell + 0.0165\ \ell = \underline{\underline{0.517\ \ell}}$

13. alcohol: 40 % of 1000 mℓ are 400 mℓ:

    $\Delta V = \gamma \cdot V_0 \cdot \Delta T = 1.10 \cdot 10^{-3} \frac{1}{K} \cdot 400\ m\ell \cdot 20.0\ K = 8.80\ m\ell$

    water: 60 % of 1000 mℓ are 600 mℓ:

    $\Delta V = \gamma \cdot V_0 \cdot \Delta T = 0.207 \cdot 10^{-3} \frac{1}{K} \cdot 600\ m\ell \cdot 20.0\ K = 2.48\ m\ell$

    $8.80\ m\ell + 2.48\ m\ell = \underline{\underline{11.3\ m\ell}}$

14. $\rho = \frac{m}{V} = \frac{13'550\ kg}{1.000\ m^3}$ at 20 °C.

    The volume increases by

    $\Delta V = \gamma \cdot V_0 \cdot \Delta T = 0.182 \cdot 10^{-3} \frac{1}{K} \cdot 1.000\ m^3 \cdot 125\ K = 0.02275\ m^3$

    At 145 °C the volume is $V = 1.02275\ m^3$

    The density at 145 °C is $\rho = \frac{m}{V} = \frac{13'550\ kg}{1.02275\ m^3} = \underline{\underline{13'249\ \frac{kg}{m^3}}} = 13.25 \cdot 10^3\ \frac{kg}{m^3}$