Pressurised trainer heel cushions

Education in Chemistry
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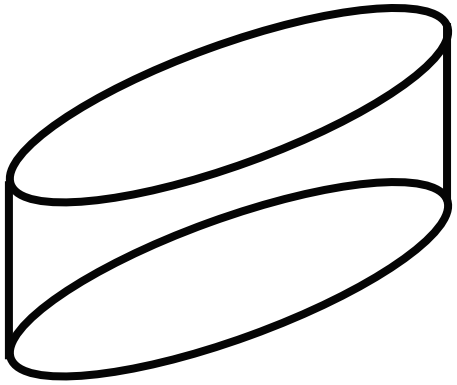
One of the inventions to have originated with NASA and space exploration is the pressurised heel cushion, popularised by Nike Air trainers. Read the article, It all began at NASA … and complete the questions below.

pV = nRT

1. The heel cushion in a trainer can be thought of as an elliptical prism as below.
   The major radius of the ellipse is 3.5 cm in length, and the minor radius of the ellipse is 2.3 cm. The height of the cushion is 18 mm.
   The cushion is filled with argon, which is produced from the fractional distillation of air, as it composes 0.934% of atmospheric air.
   Atmospheric air is taken from room temperature and pressure and fractionally distilled, and 0.26 g of the resulting argon is pumped into the cushion at 25 °C. What is the pressure in the heel cushion in atmospheres?



Fractional distillation of air

2. Describe how fractional distillation can be used to separate the major component gases in air.
   Boiling point of oxygen is -183 °C, nitrogen is -196 °C.

Boiling points

3. Explain why nitrogen's boiling point is lower than oxygen's.

Answers

1. pV = nRT, rearrange to p = nRT/V
   Volume: surface area of an ellipse is pi x major radius x minor radius = 25.289 cm^2
   Volume = 25.289 x 1.8 = 45.53 cm^3
   Volume = 45.53 / 1000000 = $4.55x10^{-5}$ m^3
   Temperature = 298 K
   R = 8.31 $Jmol^{-1}K^{-1}$
   n = 0.26 / 39.9 = 6.5 x 10^{-3}
   p = 354486.32 Pa
   In atmospheres: 3.4985 atm, 3.50 to three SF.
2. Air is cooled down below -196 °C so condenses. Temperature gradually raised, at -196 °C the nitrogen will boil and can be collected, at -183 °C oxygen will boil and can be collected.
3. More electrons, increased induced dipole–dipole attraction.