

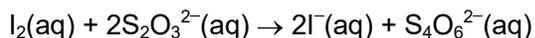
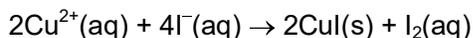
2. This question is about Great Britain being better than any other country at cycling

One of the most successful British sports at the London 2012 Olympics was cycling. British cyclists won eight gold, two silver and two bronze medals. In addition, Bradley Wiggins became the first ever Briton to win the Tour de France.



- (a) Bronze medals contain copper. A 0.800 g sample of a bronze medal was dissolved in hot concentrated nitric acid. After cooling and dilution, an excess of potassium iodide solution was added and the solution was made up to 250.0 cm³. A 25.00 cm³ aliquot of this solution required 12.20 cm³ of 0.100 mol dm⁻³ sodium thiosulfate solution in the presence of starch indicator.

Calculate the percentage by mass of copper in the bronze medal.



- (b) All medals that were won at London 2012 had a diameter of 85 mm and were 7 mm thick. The silver medal was made up of 92.5% silver and 7.5% copper, by mass.

Calculate the mass of a silver medal. Assume that the density of the alloy varies proportionally to its composition by mass.

Densities in g cm⁻³: Ag, 10.49; Cu, 8.96

- (c) Gold medals are made of gold, silver and copper. A 5.000 g sample of a gold medal was warmed with excess concentrated nitric acid. An undissolved residue was separated by filtration, washed, dried and weighed. Its mass was 0.067 g. Then an excess of dilute hydrochloric acid was added to the solution in nitric acid. The precipitate formed was separated by filtration, washed, dried and weighed. Its mass was 6.144 g.

Calculate the percentage by mass of gold, silver and copper in the gold medal.

The GB cyclists have individually designed bikes, which have to cope with the demands placed on them whilst being as light as possible. One way a light bike could be achieved is by altering the gas used to inflate the bike tyres.

You may assume that for the remainder of this question that gases behave as ideal gases and that they follow the ideal gas law:

$$pV = nRT$$

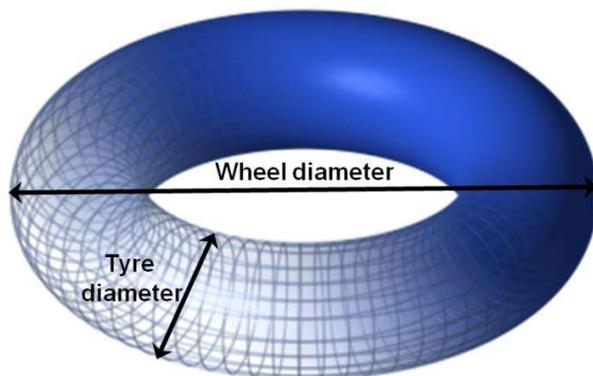
where p = pressure in Pa
 V = volume in m^3
 n = number of moles
 R (the gas constant) = $8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
 T = temperature in Kelvin

The tyres on a bike are approximately the shape of a torus. The equation for the volume of a torus, V , is given below.

$$V = \frac{\pi^2 r d^2}{2}$$

r = distance from centre of torus to **centre** of tyre tube

d = diameter of tyre tube



(d) A typical bike may have a wheel diameter of 66 cm and a tyre diameter of 23 mm.

Calculate the volume of a tyre, in m^3 .

If you are unable to calculate the volume of a tyre, you may use the value of 0.001 m^3 in the subsequent parts of this question.

(e) (i) The air pressure used in the tyres is typically 120 psi, much higher than atmospheric pressure.

1 psi = 6895 Pa.

Calculate the number of moles of gas in a tyre, at 25°C .

(ii) Assuming air is a mixture of 80 % nitrogen gas and 20 % oxygen gas, calculate the total mass of air in **both** tyres on a bike.

(iii) In cycling the smallest of changes can make the difference between winning and losing. The small reduction in mass upon inflating tyres with helium instead of air would be worth considering if it was not for that fact that the very small helium atoms escape through the rubber of tyres much more rapidly.

Calculate the reduction in mass of the bike if both tyres were inflated with helium instead of air.

(iv) SF_6 is one of the densest substances that would still remain in the gas phase at this pressure.

What would be the increase in mass if the bike tyres were filled with SF_6 ?