Bolyes Law

Aim:
To prove Boyles Law

Plan:
I plan to set up my experiment with a bicycle pump attached to the Borden gauge and have a ruler attached to the side of the Borden gauge. I will then pump the pressure up taking readings from the pressure gauge and the ruler. I will start the experiment at 100 atm, which is earth's atmospheric pressure, and I will go up to 400 atm. I will take the reading at every 50 atm. I will need to use these apparatus:-

- Bicycle pump
- Borden Gauge
- Ruler
- Sellotape

Fair Test:

I will need the ruler so that I can measure the volume of the Borden gauge more accurately as the readings on the side of the Borden only go up in cm3. It must also be stuck on to the side of the Borden gauge straight down and not at angle. If it is at an angle then it would be an unfair test. I must also remember to read both the reading off of the pressure and the volume straight on so that the test is not unfair in that way. As the Borden gauge uses water to allow you to read the volume, I must remember to read from the bottom of the meniscus and take all my readings from the bottom of the meniscus. I will also do the experiment twice so that I can take an average of the two and make it more accurate that way. I could also try and keep the temperature around the Borden gauge the same so that the experiment is fair. Once I have all of my results I will write them down in a table and draw two graphs. One will be a pressure, volume graph and the other will be pressure, 1/volume graph. The Borden gauge has been made so you can't tell the volume at 100 atm, this means I will have to guess which could lead to some inaccuracy.

Pressure	V1	V2	Vav	1/V

Safety:
I shouldn't pump up the experiment to high as it could break the pump and other parts of the experiment.

Prediction:
From my studies in class, I know that Boyles law states that:-

The volume of a fixed mass of gas is inversely proportional to its pressure, provided the temperature of the gas remains constant.

This means that as the pressure increases the volume decreases. Knowing this I predict that as I pump more pressure into the apparatus, the volumes will decreases. I also believe that Boyle's law means that if the pressure is doubled the volume will decrease by the same amount e.g: If the pressure is doubled the volume is halved etc. This is because the atoms in the gas will be compressed into a smaller area therefore tacking up less volume. It important to know that Boyles law includes the phrase, providing that the temperature remains constant. This backs up what I said under fair test that I must try and keep the temperature constant.

Results:

Pressure	V1	V2	Vav	1/V
100	56	56	56	0.018
150	39	39	39	0.026
200	28	30	29	0.034
250	23	23	23	0.043
300	17	21	19	0.053
350	19	16	17	0.056
400	113	15	14	0.071

Analysis:
When I plotted the graph pressure, volume I found I had a smooth curved graph. To make it more clear I also plotted the pressure, 1/V graph, which went through the origin. Even so, I had to draw a line of best fit as not all of the points were on the same line. When I did this I found that all of the points on the graph were close to the line of best fit except one. This point was the last one and may have been inaccurate due to the fact that at about 300 atm it became harder to pump the Bicycle pump and this may have lead to some inaccuracy.
The pressure volume graph shows me that my prediction and Boyles law is true because from the graph you can tell that as the pressure increases the volume decreases. My prediction matched up very well to what happened when I did the experiment. So now I can say Boyle's law is correct.

The volume of a fixed mass of gas is inversely proportional to its pressure, provided the temperature of the gas remains constant.

The pressure, 1/volume graph also prove my prediction that both volume and pressure are inversely proportional. I can now say that if the pressure is doubled the volume is halved and so if there is three times the pressure is applied then you get one-third the volume and so on.

When it comes to the equations I can also say there are three state variables involved.
Pressure: P
Absolute temperature: T (ºK)
Volume:V (mass)

I found this equation in a physics book:-
P1 V1=P2 V2
Providing there is a constant temperature.

I then found the combined gas law which states

$$\frac{P1\ V1}{T1} = \frac{P2\ V2}{T2}$$

I will use this equation to find out how accurate my results are. For the equation I will use the results for 100atm and the results for 300 atm. I am not using the results from 400 atm as that is the point that is furthest away from the line of best fit.
P1= 100
V1= 56
T1=293ºK (Temperature of the room at the time of doing the experiment)

P2= 300
V2= ?
T2=293ºK

$$\frac{100\ \ 56}{293} = \frac{300\ \ ?}{293}$$

$$19.11 = \frac{300\ \ ?}{293}$$

$$\frac{19.11 \times 293}{300}$$

=18.7 cm3

If you compare this result with the result I had during the experiment, you will see that my result is only 0.3 higher then the calculation. I can now use this to find out my percentage error.

$$\frac{18.7}{19.0}$$

= 0.98

0.98x100
=98%

100% - 98%
=2%

This means I have a 2% error in my experiment, and 2% is not very high. If you look at the last point in the graph it is further away from the line of best fit then the others.

Evaluation:
My experiment went well as I managed to get all of my results and I proved that Boyles Law is true. I know this from the results and the shape of the graphs I had. I believe my results were quite accurate, because when I drew my line of best fit all of the points were close to the line except one. I explained this happened because at about 400 atm it became harder to pump the bicycle pump. When I did the equations I also found I had a 2% error in my experiment. This is a very good result considering the apparatus I used. I believe that my method was the best way of carrying out the investigation with the apparatus I had, but I think there may be a few ways of improving the experiment. Instead of using a bicycle pump you could use an electric pump which would do the pump up the pressure more easily. You could also find a new Borden gauge that would allow you to pump the pressure up to a higher atm then the one we used. This would allow you to get more results and have a more accurate. There was the phrase in Boyles Law, ‘Providing the temperature is constant’. Even though the chances of there being a large

temperature change are very low, as I was unable to find a way of keeping the temperature around the Borden gauge constant, you could try and find a way of keeping the temperature constant.

You could take this experiment further by proving Charles Law and the pressure law. This would allow me to then prove the combined gas law.

All of this information is very relevant to divers. When diving, especially in shallow water (10m, where the danger is at its greatest), there could be temptation for you to hold your breath when swimming back up to the surface. If you were to do so, the ambient pressure as you rise to the surface would decrease, resulting in the volume of air in your lungs to increase. If you did not let go of your breath on the way up, there would be a serious possibility of a burst lung (air embolism). This is why divers must remember to breathe out when swimming to the surface.