Candidate 4

TITLE: the build-up of carbon dioxide in a classroom

AIM: to investigate whether a build-up of carbon dioxide during a class has an impact on student performance.

UNDERLYING ENVIRONMENTAL SCIENCE

The Earth's atmosphere is made up of a combination of gases: nitrogen (78%), oxygen (21%), argon 0.93%, carbon dioxide 0.04% and trace amounts of other gases and water vapour [1].

Although carbon dioxide is a naturally occurring gas it can be harmful to humans and other organisms at high concentrations. The normal level indoors is between 350-1,000 parts per million (ppm) and at this level there are no noticeable effects on human health. At levels above 1,000 ppm people may start to feel drowsy. Above 2,000 ppm can cause headaches, sleepiness, poor concentration, increased heart rate and nausea. Prolonged exposure above 5,000-40,000 ppm can cause serious brain injury, coma or death [2].

Modern buildings are designed with increased energy efficiency to reduce energy costs. This has led to buildings becoming more air tight, and this could impact on indoor air quality by not allowing pollutants such as carbon dioxide to escape. When left undisturbed atmospheric gases separate out into layers, with denser gases closest to the ground and lighter ones on top. Carbon dioxide is denser than oxygen so will sink towards the floor. In a classroom where everyone is sitting at desks and not moving about much for a double period, by the end of class the students could be breathing in high levels of carbon dioxide and low levels of oxygen. Classrooms in my school have carbon dioxide and temperature monitors on the wall. If levels get above a set level the windows should open automatically to air the room.

This investigation will try to identify if levels of carbon dioxide can reach harmful levels in a modern school classroom and if high levels have a negative effect on performance.

DATA COLLECTION

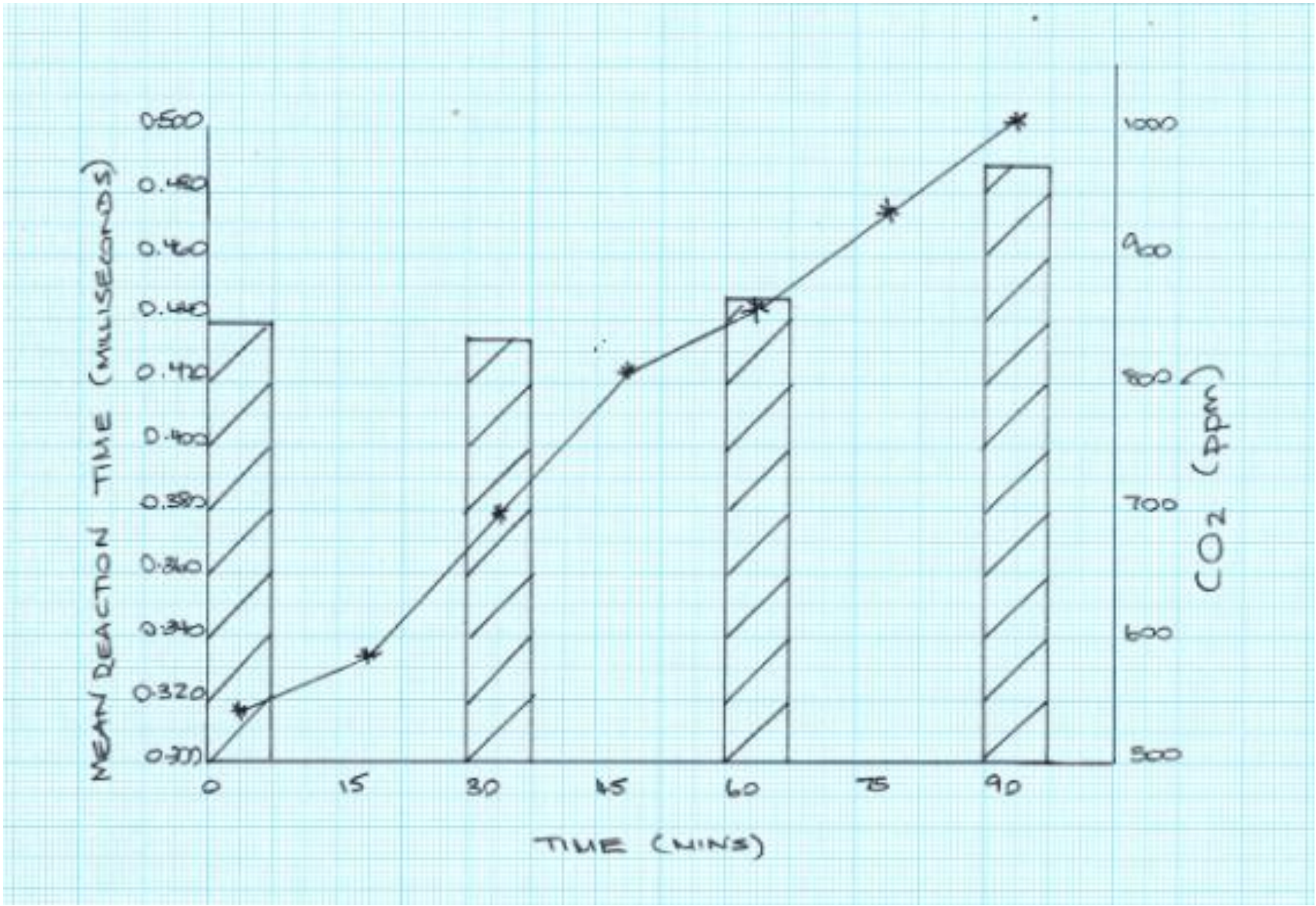
Carbon dioxide readings from the wall monitor were recorded every 15 minutes during a double period.

I was in a team of 4. Every 30 minutes we each completed an online reaction time test, with 5 repetitions per test.

RAW DATA:

Time (mins)	CO_2 (ppm)
0	539
15	584
30	698
45	810
60	860
75	934
90	1008

Time (mins)	Mean reaction time (milliseconds)				
	Pupil A	Pupil B	Pupil C	Pupil D	Mean
0	0.406	0.349	0.654	0.346	0.439
30	0.396	0.386	0.621	0.332	0.434
60	0.412	0.390	0.599	0.387	0.447
90	0.470	0.423	0.668	0.395	0.489
Mean	0.421	0.387	0.636	0.365	


MEAN REACTION TIME (MILLISECONDS)
0·500
0·480
0·460
0·440
0·420
0·400
0·380
0·360
0·340
0·320
0·300
0
15
30
45
60
75
90
TIME (MINS)
1000
900
800
700
600
500
CO2 (ppm)

ANALYSIS:

It can be seen from the table and graph that carbon dioxide levels in the classroom increased over time. There wasn't much movement in the class and so the gas layers would not have been disturbed very much.

The mean reaction time did not vary much until 90 minutes, when all pupils in my group reacted slower than in the previous tests.

It is estimated that the average person exhales 32.67g of carbon dioxide an hour when at rest [3]. There were 21 people in the room for around 100 minutes so the total mass of carbon dioxide exhaled by the class during that time would be:

1 person exhales 32.67 g/h
= 0.545 g/min

21 people in room for 100 mins
0.545 x 21 x 100 = 1.15kg

CONCLUSION

The data collected in class shows that carbon dioxide levels increased with time, and that the class exhaled around 1.15 kg of carbon dioxide during the double period. There was little movement in the class as we were working on our own, so carbon dioxide will have settled out at a lower level than oxygen as it is denser. This means that pupils sitting still at desks will have breathed in more carbon dioxide the longer the class lasted. The reaction time test shows that 1,000 ppm carbon dioxide can affect performance. My conclusion is that a build-up of carbon dioxide during a class does have an impact on student performance.

EVALUATION

The monitor in the classroom was set half way up the wall so might have recorded lower levels of carbon dioxide than were being breathed in by students sitting at the desks, as carbon dioxide will settle out lower than oxygen.

The monitor also displayed temperature. It would have been useful to monitor whether this changed over the same time, as changes in temperature could also have affected reaction times.

Each test had 5 repetitions and there were 4 students in the group. Each student had different reaction times but calculating the average of all 20 results calculated in the same time period should give a more accurate result.

REFERENCES

[1] 'Higher Still Core Higher Geography' by Kenneth Maclean and Norman Thomson p5 ISBN 0340758392

[2] 'What are safe levels of CO and CO_2 in rooms?' https://www.kane.co.uk/knowledge-centre/what-are-safe-levels-of-co-and-co2-in-rooms accessed March 2019

[3] 'Is CO_2 an indoor pollutant? Direct effects of low-to-moderate CO_2 concentrations on human decision-making performance' by Usha Satish, Mark Mendell and William Fisk in Environmental Health Perspectives (2012) 120(12) page 1671-77[4] Reaction time test, University of Washington https://faculty.washington.edu/chudler/java/redgreen.html accessed March 2019