Surname		Other Names	
Centre Number			Candidate Number				
Candidate Signature									

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General Certificate of Education
June 2006
Advanced Level Examination

AQA
ASSESSMENT and QUALIFICATIONS ALLIANCE

ENVIRONMENTAL SCIENCE **ESC7**
Unit 7 Alternative to Practical Investigation

Thursday 29 June 2006 9.00 am to 11.00 am

You will need no other materials.
You may use a calculator.

Time allowed: 2 hours

Instructions
- Use blue or black ink or ball-point pen.
- Fill in the boxes at the top of this page.
- Answer all questions.
- Answer the questions in the spaces provided.
- Do all rough work in this book. Cross through any work you do not want marked.

Information
- The maximum mark for this paper is 75.
- The marks for questions are shown in brackets.
- You are reminded of the need for good English, clear presentation and appropriate use of specialist vocabulary. Question 4 should be answered in continuous prose. Quality of Written Communication will be assessed in this answer.
- This unit assesses your understanding of the relationship between the different aspects of Environmental Science.

For Examiner's Use			
Number	Mark	Number	Mark
1		3	
2		4	
Total (Column 1) →			
Total (Column 2) →			
TOTAL			
Examiner's Initials			

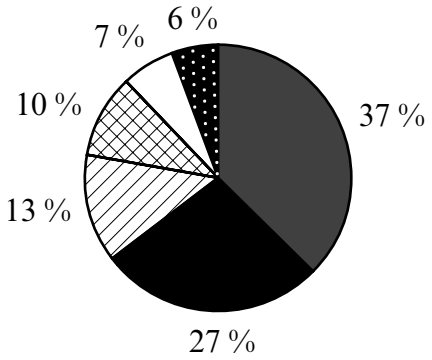
Investigation into some impacts of vehicles on plant and animal ecology, noise and air quality

Introduction

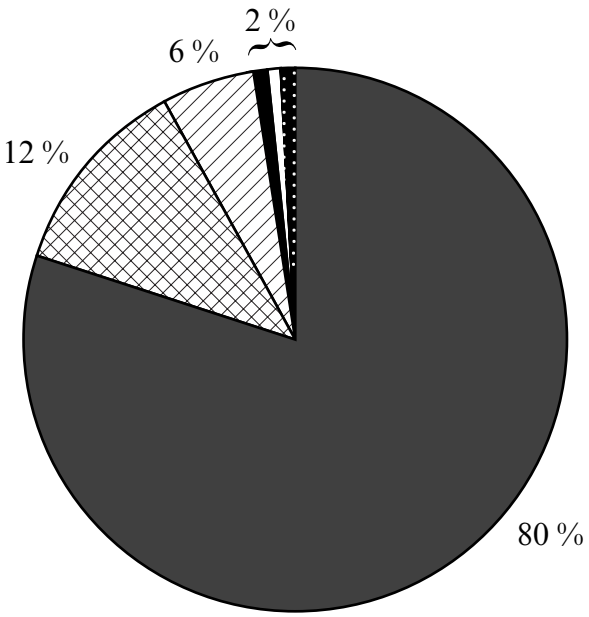
Since 1950, the traffic on Britain's roads has increased dramatically. The largest increase is in the number of cars, from about 2 million vehicles in 1952 to nearly 25 million in 2002.

The graphs show the total road traffic by vehicle type in 1952 and 2002 (measured in billion vehicle kilometres).

1952 – Total traffic of 83.7 bn vehicle kms



2002 – Total traffic of 480.2 bn vehicle kms



Key

Cars and taxis
Motorcycles
Buses and coaches
Light vans
Goods vehicles
Pedal cycles

Source: adapted from Department for Transport

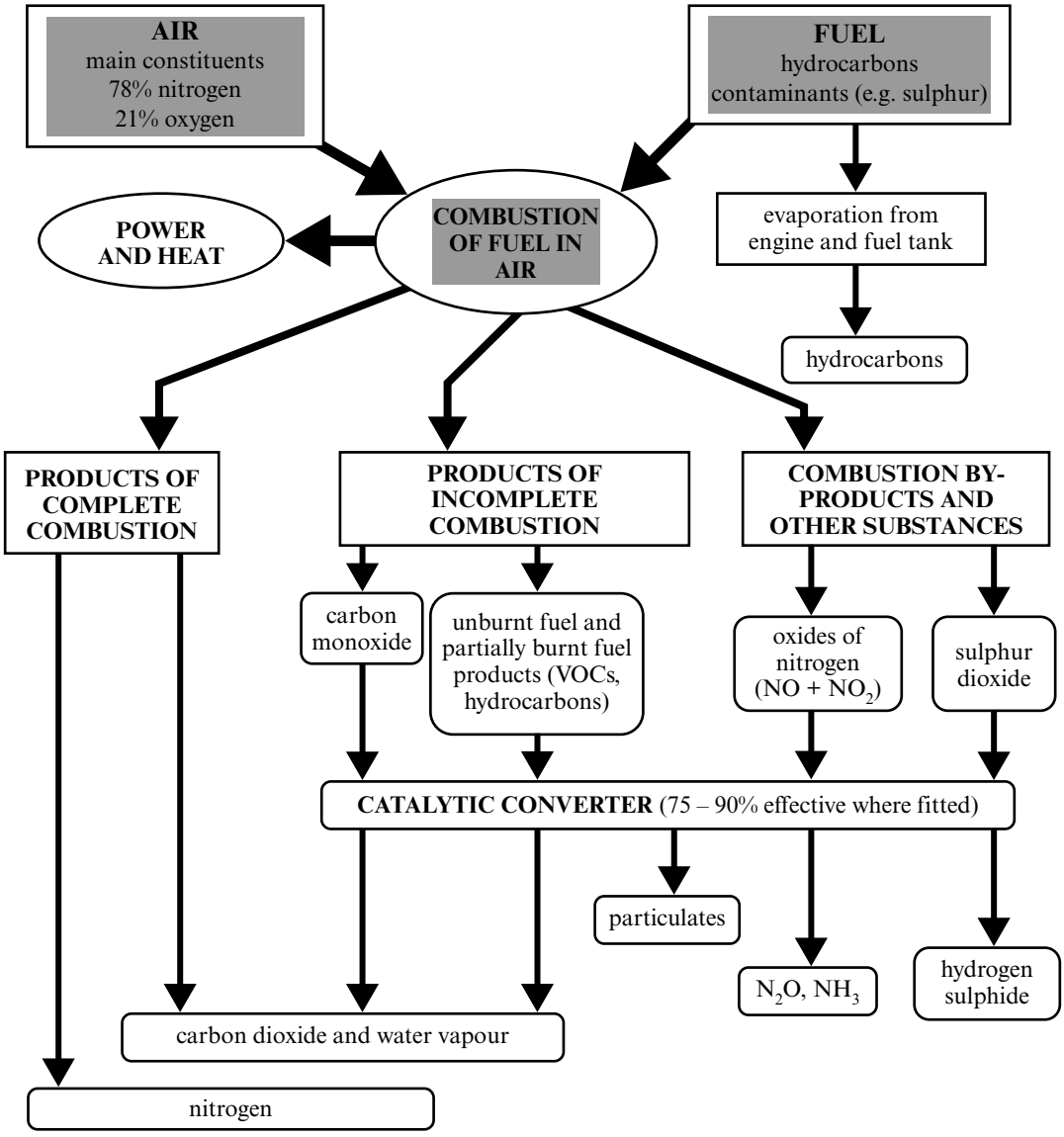
This increase in car ownership has led to substantial benefits for many people and has provided opportunities that were not available to previous generations. It has allowed greater personal freedom in many aspects of life, from where people choose to live to where they spend weekends or holidays. Cars are now used for 70 % of all journeys in Britain, over two-thirds of households have at least one car and, for many, the car is essential.

However, with the benefits of greater mobility have come some major disadvantages. Car transport is associated with a wide range of pollution problems including global climate change, acid rain and local smogs, all associated with the emissions of particular gases into the atmosphere. There is also evidence that exhaust emissions affect the species composition and growth rates of vegetation and crop plants grown near to busy roads. Other problems include accidents, to both humans and animals, visual intrusion, noise

and urban congestion. Problems such as these have prompted many local authorities to introduce speed limits and traffic calming measures on many roads, especially in residential areas. These may bring further problems and include greater vehicle noise as a result of an increase in braking in response to some types of traffic calming measures, followed by acceleration when past the obstacle.

Cars are usually powered by internal combustion engines fuelled by diesel or, more commonly, petrol. Petrol is refined from crude oil, which is a finite fossil fuel and when burnt produces carbon dioxide (CO_2) and water. However, by-products are also emitted including high levels of carbon monoxide (CO), hydrocarbons (HC) and various oxides of nitrogen (NO_x). Although the harmful, unwanted by-products can be considerably reduced by the presence of a catalytic converter, these only work efficiently when the engine has fully warmed up which takes a few minutes. As 58 % of car journeys in the UK are less than 8 kilometres, the catalyst can be largely ineffective. Also, catalytic converters do nothing to reduce the level of CO_2 emitted, which can only be reduced by using less fuel.

The diagram shows the vehicle exhaust emissions emitted by petrol-driven cars.



Source: adapted from Royal Commission on Environmental Pollution (1994)

One way to use less fuel is to use the fuel more efficiently. Diesel cars use fuel approximately 30 % more efficiently than a petrol fuelled equivalent and this is an advantage particularly for shorter journeys in urban conditions. Diesel cars, however, do emit more volatile organic compounds (VOCs) and more NO_x, both of which contribute to the problem of photochemical smog.

Air pollutants from a road generally only affect areas within 200 metres of the centre of the road because of the dispersion of the pollutants. Beyond approximately 200 metres, road traffic pollutant concentrations tend to approach background levels. However, on most busy roads the limits for many pollutants are exceeded particularly near junctions and during peak hour congestion when there are many slow moving vehicles.

Aims of the investigation

- To study the effects of vehicle exhaust pollutants on the plant diversity of roadside verges.
- To evaluate data on the road kill of small mammals.
- To investigate the effect of different road traffic calming measures on noise pollution.
- To investigate the effects of nitrogen dioxide emissions on air quality.

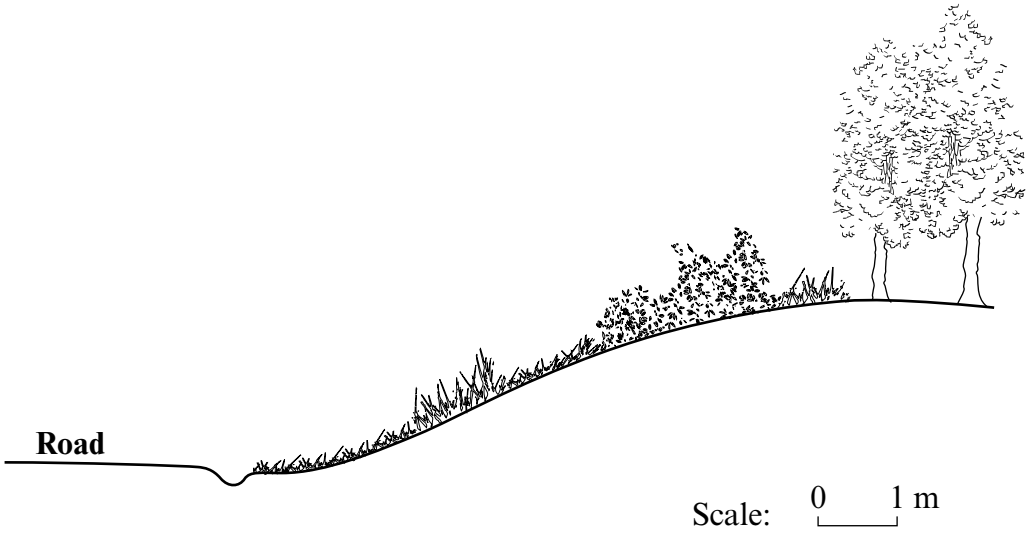
The following questions test the skills of planning, implementing, analysing and drawing conclusions from investigative work. They also test the ability to discuss the findings and evaluate methods, as well as suggesting modifications to the methods used and relevant further work.

Answer all questions in the spaces provided.

1 Effect of vehicle exhaust pollutants on roadside verge vegetation

A student decided to investigate the effect of air pollution on the diversity of plant species of two roadside verges in a nearby rural location. One site was close to a busy main road; the other was near a minor road.

The diagram is a sketch of the profile of a typical roadside verge.



(a) Suggest three factors that the student should have considered when choosing the sites to make the comparison a fair test.

1. .....

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2. .....

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3. .....

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(3 marks)

Question 1 continues on the next page

(b) (i) The student decided to use continuous belt transects to assess the plant composition of the roadside vegetation. Suggest why this is an appropriate technique.

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(3 marks)

(ii) Giving full practical details, describe how a belt transect is carried out.

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(5 marks)

(iii) Suggest an alternative technique that the student might have used to sample the vegetation alongside the two roads.

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(1 mark)

(iv) Discuss the limitations of using the results of this investigation in drawing valid conclusions about the effects of road traffic pollution on vegetation.

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(3 marks)

(c) State the possible risks to personal safety that the student would have to consider when working at these sites and how they could be reduced.

Risks .....

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Risk reduction .....

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(4 marks)

Question 1 continues on the next page

(d) In addition to air pollution, soil factors may have influenced the types of plant growing on the verge and the ability of plants to grow well. The student decided to measure the pH and organic content of the soil to see if any differences between the two sites would account for any variation in vegetation.

(i) Describe how the organic content of the soil would have been measured.

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(4 marks)

(ii) The student measured pH by using universal indicator paper because a pH meter was unavailable.

Suggest two limitations of using the universal indicator paper method for measuring pH.

1. .....

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2. .....

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(2 marks)

(e) Suggest two ways in which the student might have extended the study to add to their knowledge of the effects of vehicle pollutants on the wildlife of the roadsides.

1. .....

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2. .....

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(2 marks)

27

Turn over for the next question

2 Effect of motor vehicles on mammal populations

There have been many warnings that, due to road casualties, common mammal species such as hedgehogs, badgers and hares might be declining and face local extinction. In Britain, annual road casualties are estimated to account for 100 000 foxes, 100 000 hedgehogs, 50 000 badgers and between 30 000 and 50 000 deer.

The Mammal Society undertook a nationwide survey to identify trends in wildlife road casualties. For one year, 280 volunteers from across Britain recorded wild mammal casualties on all road categories except dual carriageways and motorways.

(a) (i) Suggest why dual carriageways and motorways were excluded from the study.

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(1 mark)

(ii) Explain why this exclusion would make the results unrepresentative.

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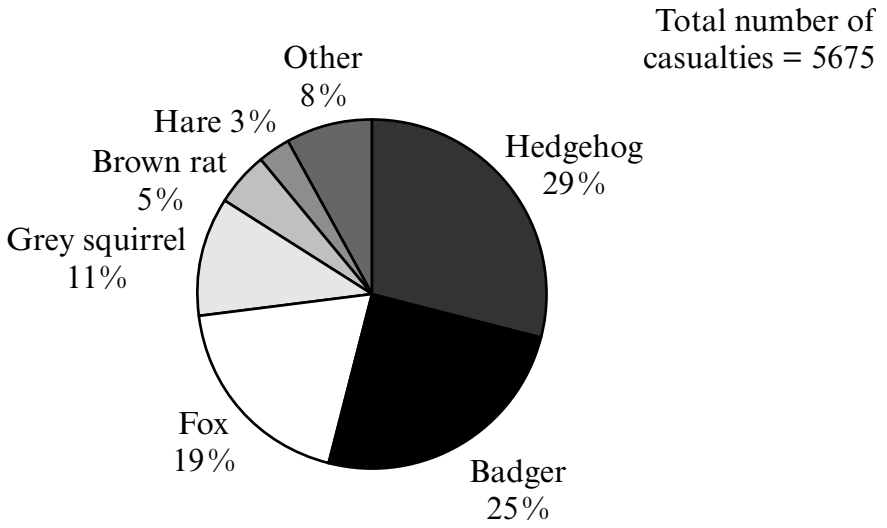
(1 mark)

(b) The graph shows the number of mammal casualties recorded by the volunteers as proportions of the total.
(Common names have been used for simplicity.)



Source: The Mammal Society www.abdn.ac.uk

(i) Calculate the actual number of hedgehogs killed during this period. Show your working.

Answer .....

(1 mark)

(ii) Suggest why hedgehogs may be particularly vulnerable to road traffic accidents.

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(1 mark)

(c) Suggest four other factors that influence the number of wildlife casualties.

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2. .....

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3. .....

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4. .....

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(4 marks)

(d) The population size of small mammal species can be estimated by using the mark-release-recapture (Lincoln Index) method.

State three assumptions that are made when applying this method.

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2. .....

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3. .....

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(3 marks)

3 Effect of traffic calming measures on noise pollution

A student investigated whether the use of traffic calming measures had an impact on the level of noise pollution. The investigation was carried out in a large city on similar roads with speed limits of 30 mph. Roads having traffic calming measures, such as road bumps (sleeping policemen), speed cameras and road narrowing around traffic islands, were compared with a similar road with no such measures. Recordings of 10 cars were taken at each of four sites using a digital sound meter. All recordings were taken two metres from the road edge and all noise levels were measured in decibels (dB).

(a) The results of the investigation are shown in Table 1.

Table 1

	Noise recorded			
Car number	Road A Road bumps dB	Road B Road narrowing dB	Road C Speed cameras dB	Road D No restrictions dB
1	81.1	65.4	75.5	64.2
2	65.6	68.0	79.8	65.2
3	67.9	70.7	69.5	58.1
4	52.2	76.2	77.1	61.2
5	65.9	68.7	79.5	65.9
6	64.2	63.5	68.2	70.0
7	66.8	65.7	72.1	57.1
8	80.1	68.0	79.8	63.2
9	69.8	67.5	72.4	60.4
10	62.4	70.6	69.1	68.9
Mean	67.60	68.43	74.30	63.42
Standard deviation	8.34	3.54	4.63	4.29

(i) What information is provided by the calculation of standard deviation?

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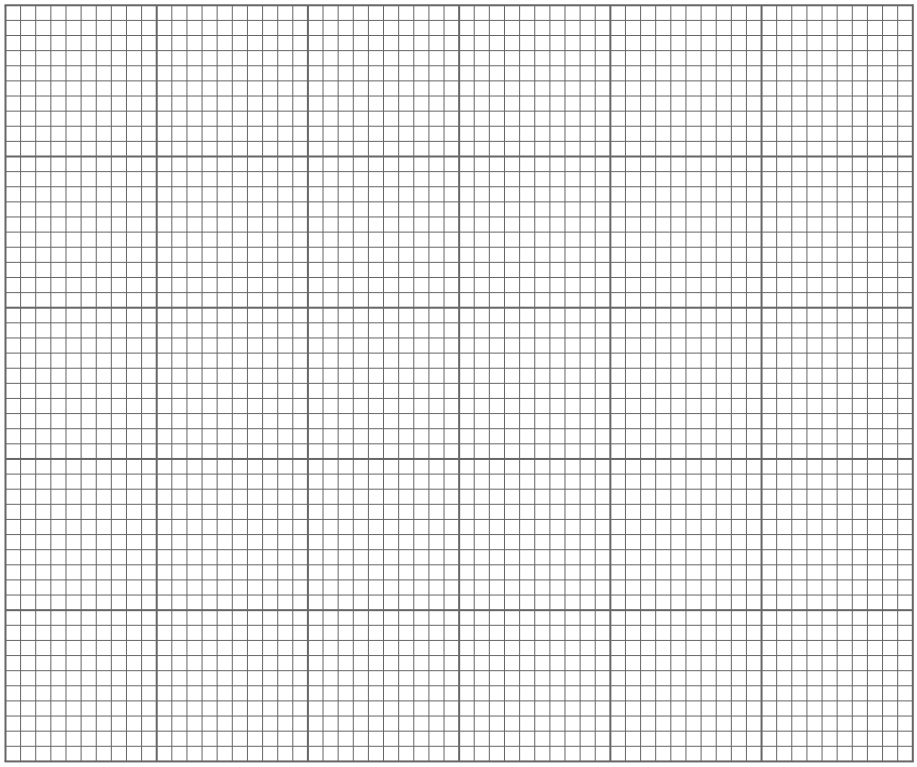
(1 mark)

(ii) Use an appropriate graphical technique to summarise the results in Table 1.



(4 marks)

(iii) Suggest three other factors which may have influenced the results.

1. .....

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2. .....

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3. .....

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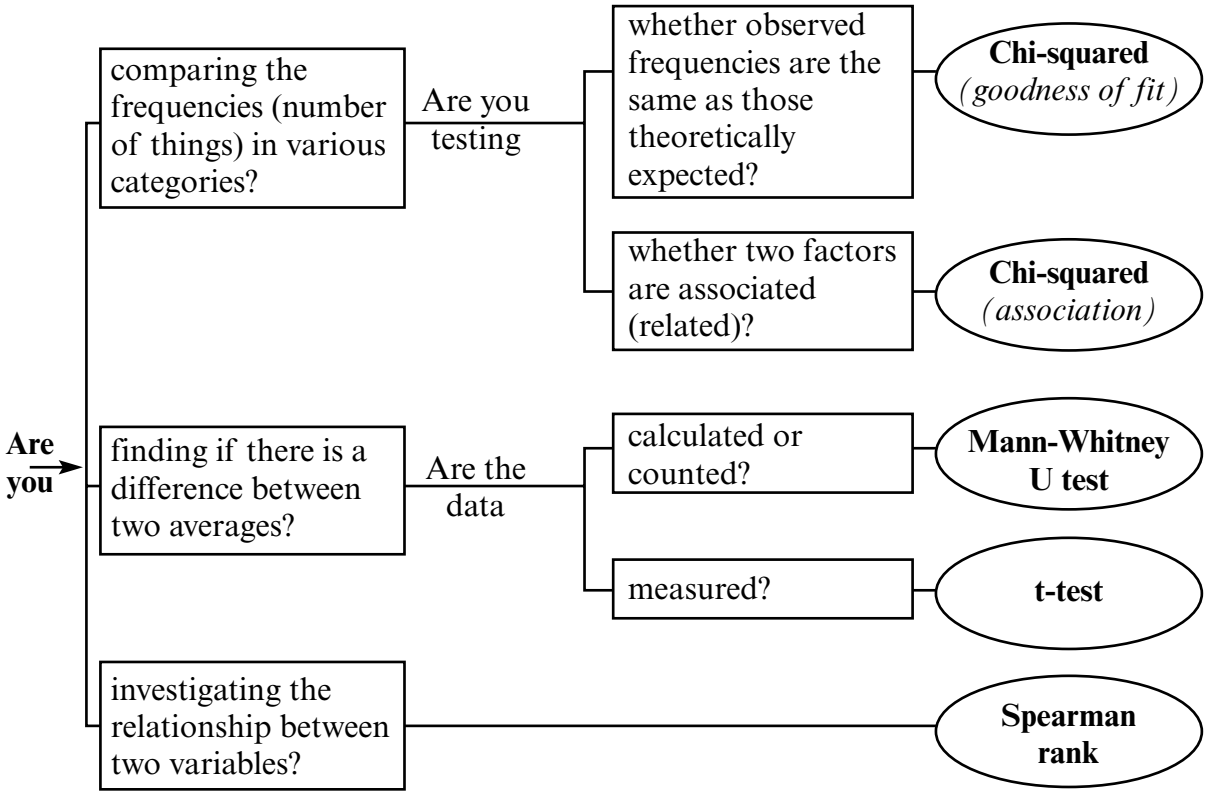
(3 marks)

Question 3 continues on the next page

(b) (i) On the basis of the results obtained, the student decided that there was a significant difference in the noise levels at the site where speed cameras were placed compared with the site where road narrowing was used.

Use the flow diagram to choose an appropriate statistical technique to test this hypothesis. Give two reasons to justify your choice of test.



Choice of statistical test

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Reasons for choice

1. .....

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2. .....

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(3 marks)

(ii) Carry out your chosen test using the data in Table 1 and information in the Appendix. Show your working.

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(6 marks)

(iii) State your conclusion with your chosen level of significance.

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(2 marks)

Question 3 continues on the next page

(c) Using the results of the investigation into the effects of traffic calming measures, and your own knowledge, identify and discuss the trends shown.

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(5 marks)

(d) Suggest economic and environmental consequences, other than noise, that may occur because of the introduction of traffic calming measures.

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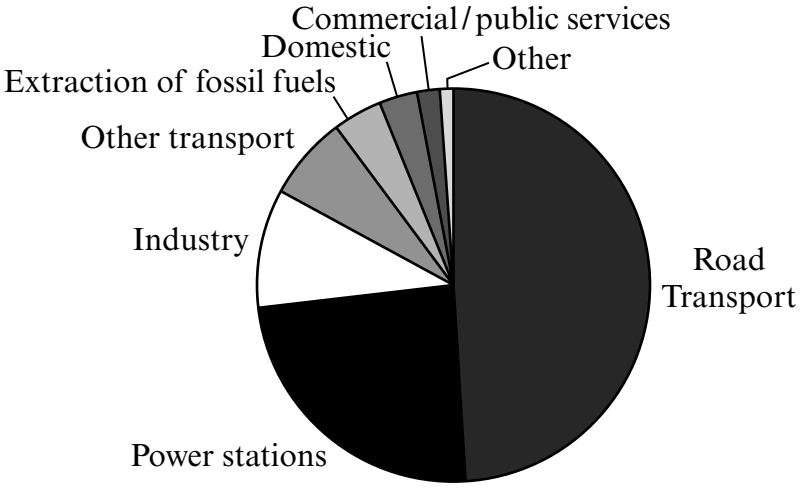
(3 marks)

4 Effect of nitrogen dioxide emitted by motor vehicles on air quality

Nitrogen dioxide results from high temperatures and pressures in engine cylinders oxidising some of the nitrogen in the air. It contributes to many environmental problems, including photochemical smog and acid deposition. Road transport is responsible for an estimated 49 % of the total annual emissions of oxides of nitrogen in the UK; 29 % comes from petrol engines and 20 % from diesel.

The graph shows the estimated percentage emissions of oxides of nitrogen in the UK in 1994.



Source: *Digest of Environmental Protection and Water Studies No. 18,* London, HMSO (1996)

Limits for the concentration of nitrogen dioxide in air have been brought into force through the Air Quality Regulations introduced in 1997.

Table 2 shows the target levels set for nitrogen dioxide emitted by motor vehicles.

Table 2

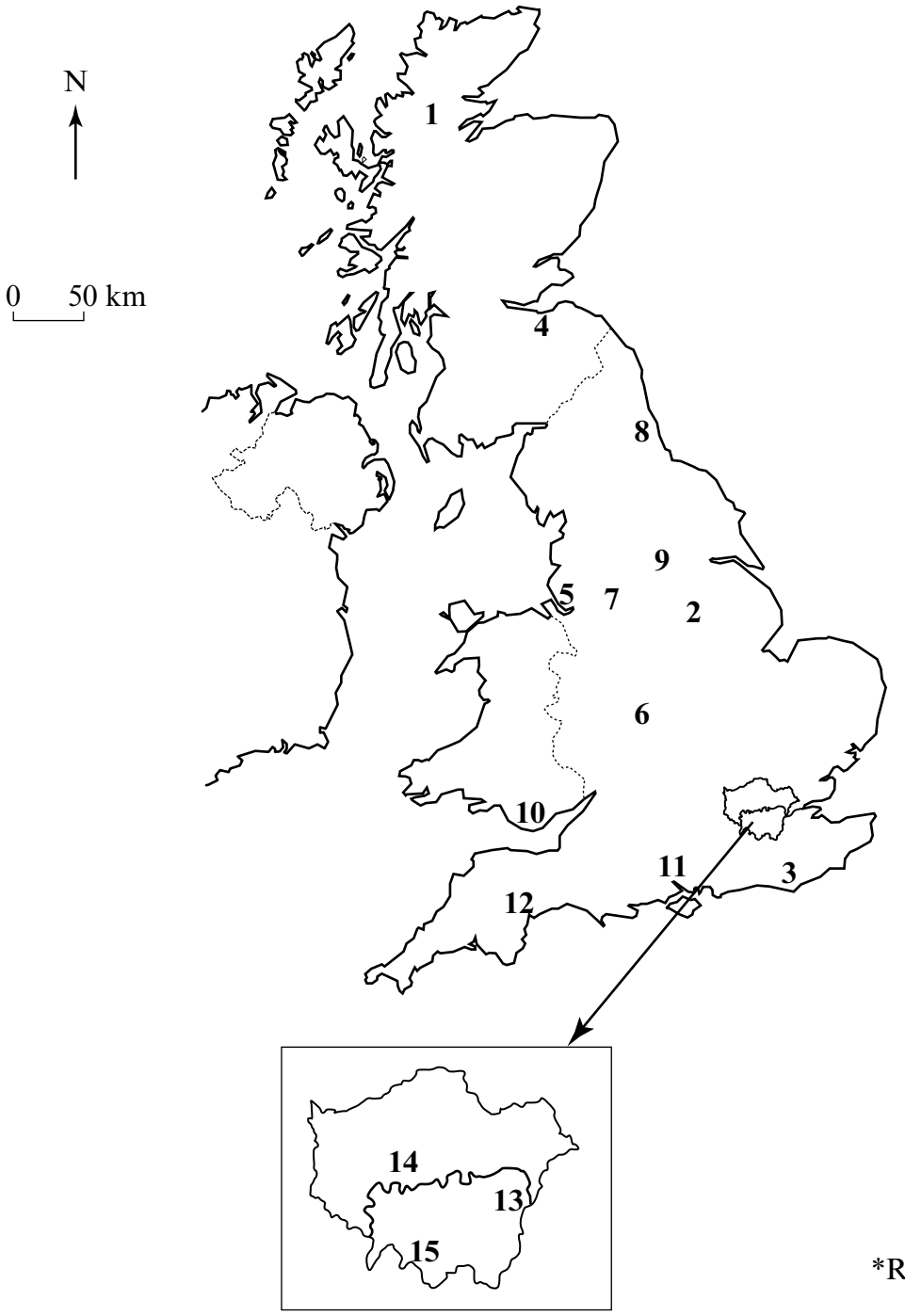
Pollutant	Period	Target levels not to be exceeded / ppb
Nitrogen dioxide (NO_2)	1 hour mean – not to be exceeded more than 18 times a year	105
	Annual mean concentration	21

Source: Highways Agency www.highways.gov.uk

Question 4 continues on the next page

Since 1985, nitrogen dioxide levels have been measured throughout the UK. Over 50 sites are being monitored regularly, including rural, central urban and kerbside locations.

The map shows the location of 15 of the sites and Table 3 shows the results obtained at these sites.



Key

Rural
1 Strath Vaich
2 Ladybower
3 Lullington Heath

Urban
4 Edinburgh
5 Liverpool
6 Birmingham
7 Manchester
8 Newcastle
9 Leeds
10 Cardiff
11 Southampton
12 Exeter*

London
13 Bexley
14 Cromwell Road*
15 Sutton*

*Roadside/Kerbside sites

Source: www.defra.gov.uk

Table 3

Site no.	Site	Classification	Average annual concentration / ppb	Maximum hourly average concentration / ppb
1	Strath Vaich, Highlands	Rural	0.5	11
2	Ladybower, Derbyshire	Rural	8	40
3	Lullington Heath, East Sussex	Rural	8	43
4	Edinburgh City Centre	Urban	26	120
5	Liverpool City Centre	Urban	26	90
6	Birmingham City Centre	Urban	22	177
7	Manchester Town Hall	Urban	23	181
8	Newcastle City Centre	Urban	21	91
9	Leeds City Centre	Urban	26	109
10	Cardiff City Centre	Urban	22	86
11	Southampton City Centre	Urban	24	95
12	Exeter City Centre	Urban Kerbside	30	150
13	Greater London (Bexley)	Urban	22	132
14	Central London (Cromwell Road)	Urban Kerbside	47	170
15	Greater London (Sutton)	Urban Kerbside	35	157

Source: adapted from www.defra.gov.uk/environment/airquality

Question 4 continues on the next page

(a) Using the information on the map and in Tables 2 and 3, discuss the trends shown by the results of nitrogen dioxide monitoring.

Quality of Written Communication will be assessed in this answer.

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(5 marks)

(b) If the results in Table 3 were the only results available, discuss their reliability in advising the Government on road transport policy. Suggest other data that should be available to aid the decision-making process.

Quality of Written Communication will be assessed in this answer.

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(5 marks)

10

END OF QUESTIONS

Turn over for Appendix

APPENDIX

Statistical formulae and tables

1 Mean

$$\bar{x} = \frac{\Sigma x}{n}$$

where:
$\bar{x}$ = mean
x = the individual measurements
n = total number of measurements
Σ = the sum of

2 Standard deviation(s)

$$s = \sqrt{\frac{\Sigma(x - \bar{x})^2}{n - 1}}$$

3 Chi-squared (χ^2) test

$$\chi^2 = \Sigma \frac{(O - E)^2}{E}$$

where:
Σ = the sum of
O = the observed value
E = the expected value

Critical Values for the Chi-Square (χ^2) Test

Degrees of Freedom (df)	Level of significance (***p***)				
	0.05	0.025	0.01	0.005	0.001
1	3.84	5.02	6.63	7.88	10.83
2	5.99	7.38	9.21	10.60	13.81
3	7.81	9.35	11.34	12.84	16.27
4	9.49	11.14	13.28	14.86	18.47
5	11.07	12.83	15.09	16.75	20.52
6	12.59	14.45	16.81	18.55	22.46
7	14.07	16.01	18.48	20.28	24.32
8	15.51	17.53	20.09	21.96	26.13
9	16.92	19.02	21.67	23.59	27.88
10	18.31	20.48	23.21	25.19	29.59
11	19.68	21.92	24.73	26.76	31.26
12	21.03	23.34	26.22	28.30	32.91
13	22.36	24.74	27.69	29.82	34.53
14	23.68	26.12	29.14	31.32	36.12

4 Mann-Whitney U Test

$$U = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - R_1$$

$$U' = n_1 n_2 + \frac{n_2(n_2 + 1)}{2} - R_2$$

where:
R_1 = sum of the ranks of sample 1
R_2 = sum of the ranks of sample 2
n_1 = size of the smaller sample
n_2 = size of the larger sample

Critical values for the Mann-Whitney U test (at the p = 0.05 level). If the smallest U value is less than or equal to the critical value then there is a significant difference between the two sets of data.

Values of n_1	Values of n_2																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1																				
2								0	0	0	0	1	1	1	1	1	2	2	2	2
3					0	1	1	2	2	3	3	4	4	5	5	6	6	7	7	8
4				0	1	2	3	4	4	5	6	7	8	9	10	11	11	12	13	13
5			0	1	2	3	5	6	7	8	9	11	12	13	14	15	17	18	19	20
6			1	2	3	5	6	8	10	11	13	14	16	17	19	21	22	24	25	27
7			1	3	5	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34
8		0	2	4	6	8	10	13	15	17	19	22	24	26	29	31	34	36	38	41
9		0	2	4	7	10	12	15	17	20	23	26	28	31	34	37	39	42	45	48
10		0	3	5	8	11	14	17	20	23	26	29	33	36	39	42	45	48	52	55
11		0	3	6	9	13	16	19	23	26	30	33	37	40	44	47	51	55	58	62
12		1	4	7	11	14	18	22	26	29	33	37	41	45	49	53	57	61	65	69
13		1	4	8	12	16	20	24	28	33	37	41	45	50	54	59	63	67	72	76
14		1	5	9	13	17	22	26	31	36	40	45	50	55	59	64	67	74	78	83
15		1	5	10	14	19	24	29	34	39	44	49	54	59	64	70	75	80	85	90
16		1	6	11	15	21	26	31	37	42	47	53	59	64	70	75	81	86	92	98
17		2	6	11	17	22	28	34	39	45	51	57	63	67	75	81	87	93	99	105
18		2	7	12	18	24	30	36	42	48	55	61	67	74	80	86	93	99	106	112
19		2	7	13	19	25	32	38	45	52	58	65	72	78	85	92	99	106	113	119
20		2	8	13	20	27	34	41	48	55	62	69	76	83	90	98	105	112	119	127

5 t-test

$$t = \frac{\left[\bar{x}_1 - \bar{x}_2\right]}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}} \qquad v = n_1 + n_2 - 2$$

where:
s = standard deviation (candidates should note that on some calculators the symbol σ may appear in place of the symbol s)
$\bar{x}$ = mean
n = sample size
v = degrees of freedom

Degrees of freedom (df)	***p*** values			
	0.10	0.05	0.01	0.001
1	6.31	12.71	63.66	636.60
2	2.92	4.30	9.92	31.60
3	2.35	3.18	5.84	12.92
4	2.13	2.78	4.60	8.61
5	2.02	2.57	4.03	6.37
6	1.94	2.45	3.71	5.96
7	1.89	2.36	3.50	5.41
8	1.86	2.31	3.36	5.04
9	1.83	2.26	3.25	4.78
10	1.81	2.23	3.17	4.59
12	1.78	2.18	3.05	4.32
14	1.76	2.15	2.98	4.14
16	1.75	2.12	2.92	4.02
18	1.73	2.10	2.88	3.92
20	1.72	2.09	2.85	3.85
22	1.72	2.08	2.82	3.79
24	1.71	2.06	2.80	3.74
26	1.71	2.06	2.78	3.71
28	1.70	2.05	2.76	3.67
30	1.70	2.04	2.75	3.65
40	1.68	2.02	2.70	3.55
60	1.67	2.00	2.66	3.46
120	1.66	1.98	2.62	3.37
∞	1.64	1.96	2.58	3.29

6 Spearman Rank Correlation Coefficient (r_s)

$$r_s = 1 - \frac{6 \sum d^2}{n(n^2 - 1)}$$

where:
$\sum$ = the sum of
d = the difference between each pair of ranks
n = sample size

Critical values for the Spearman Rank Correlation (r_s)

Number of pairs of measurements	Critical value
5	1.00
6	0.89
7	0.79
8	0.74
9	0.68
10	0.65
12	0.59
14	0.54
16	0.51
18	0.48
20	0.45
22	0.43
24	0.41
26	0.39
28	0.38
30	0.36

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