Question 2

(a) Answer the following questions that relate to the graphs above. Remember that for any calculations you must clearly indicate how you arrived at your answer. Answers must also include appropriate units.

(i) Determine the net change in atmospheric CO_2 concentration between 140,000 years ago and 125,000 years ago.

(*1 point possible*)

Point is earned for the correct set-up and answer, with numbers shown, and units included.

Note: *Lines drawn to x and y-axes were accepted in place of explicit calculation set-up.*

140,000 years before present: CO_2 ~ 200 ppm (accepted range ~195-205 ppm)

125,000 years before present: CO_2 ~ 280 ppm (accepted range ~270-290 ppm)

280 ppm – 200 ppm = an increase of 80 ppm (accepted range 65–95 ppm).

(ii) Calculate the ratio of the change in mean global temperature to the change in atmospheric CO_2 concentration between 140,000 years ago and 125,000 years ago.

(*2 points possible*)

One point is earned for the correct temperature change calculation showing numbers and including units.

Note: *Lines drawn to x and y-axes were accepted in place of explicit calculation.*

Temperature 140,000 years ago ~ – 8°C (below present)

Temperature 125,000 years ago ~ +2°C (above present)

2°C - (-8°C) = an increase of 10°C (range 8.5°C–11.5°C).

1 point is earned for the correct calculation of ratio of temperature to CO_2 concentration change.

Note: *No penalty for ratio calculation based on incorrect answer(s) from above. Range must be consistent with previous values. Percentages not accepted.*

Acceptable answers include 10:80 or 10/80 or 10 to 80; 1:8 or 1/8 or 1 to 8.

(iii) Scientists predict that between 1950 and 2050, the atmospheric CO_2 concentration will increase by 200 ppm. Predict the change in mean global temperature between 1950 and 2050 using the ratio that you calculated in part (ii).

(*1 point possible*)

Point is earned for the correct set-up and answer with correct units.

Note: *No penalty if student uses incorrect calculation(s) from above, as long as values are applied correctly. Range must be consistent with previous values.*

200 ppm × 1°C/8 ppm = 25°C increase in global temperature (accepted range 18°C–34°C)

Question 2 (continued)

(iv) Describe one major assumption that was necessary to make the prediction in part (iii) above. Discuss the validity of the assumption.

***(2 points possible*)**

One point is earned for a correct assumption and 1 point is earned for an appropriate discussion of the validity of the assumption.

Assumption	Validity of Assumption
Direct relationship exists between CO_2 and temperature.	Invalid due to anthropogenic increase of other GHGs and/or precursors. • CH_4, O_3, N_2O, CFCs, HCFCs, HFCs, halons, NO_x , NO, NO_2 , CO, VOCs, HCs Invalid due to negative feedbacks. • Aerosol increase offsets warming • Clouds can offset warming Invalid due to positive feedbacks. • Clouds can enhance warming Invalid because temperature change leads CO_2 concentration change. Invalid because correlation does not remain constant over time series period. Valid because this has been the case for past 200K years (must refer to time series). • Correlation remains constant over time
CO_2 is the only GHG that impacts temperature.	Invalid due to anthropogenic increase of other GHGs and/or precursors. • CH_4, O_3, N_2O, CFCs, HCFCs, HFCs, halons, NO_x , NO, NO_2 , CO, VOCs, HCs Valid because this has been the case for past 200K years. • Correlation remains constant over time
Change expected to occur over a very short time period.	Invalid because uncharacteristically large changes relative to time series scale: • nonlinear fluctuations • correlation changes over time

Question 2 (continued)

Assumption	Validity of Assumption
200 ppm CO_2 concentration change (prediction used as assumption).	Invalid because the change may be greater or less than this value.
Increasing CO_2 concentrations cause atmospheric temperature to rise.	Invalid because time series shows periods when change in temperature leads the change in CO_2 concentration. Valid because time series shows periods when change in CO_2 concentration leads the change in temperature.
Antarctic data can be applied to assume global temperature changes.	Invalid because there are regional variations in the magnitude of temperature fluctuations over time.
Measurement techniques are precise.	Valid because of scientific consensus of data. Invalid because of measurement uncertainty.

(b) Identify and describe TWO major causes for the predicted 200 ppm increase in atmospheric CO_2 concentration between 1950 and 2050.

(*2 points possible*)

One point is possible for each major cause of CO_2 increase identified if linked with an appropriate description.

- Continuing burning of fossils fuels by a growing population
- Increased per capita usage of fossil fuels
- Increased fossil fuel use for energy production
- Increased fossil fuel use for transportation
- Increased fossil fuel use for industry
- Increased ocean temperature results in release of dissolved CO_2
- Land-clearing and burning for increasing food production
- Deforestation (even though this involves the cycling of existing carbon, deforestation is indicated as a CO_2 sink in the texts and is accepted)
- Lack of development of alternative energy solutions

(c) Identify TWO gases other than CO_2 that contribute to the anthropogenic increase in mean global temperature. For each gas, describe a major human activity that leads to its release.

(*2 points possible*)

One point is possible for each gas that contributes to an anthropogenic increase in mean global temperature IF linked to an appropriate description of a major human activity that leads to the release of that gas.

Note: *Increased atmospheric water (H_2O) vapor is not a direct result of human activity.*

Question 2 (continued)

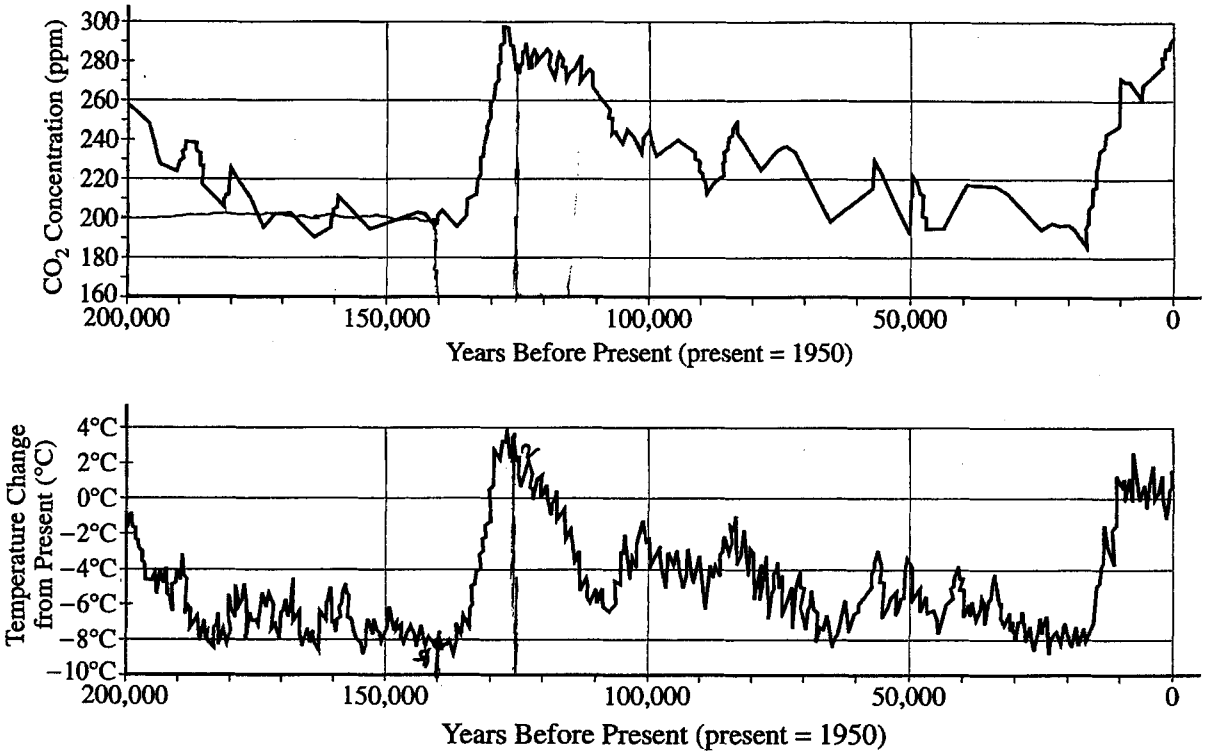
Greenhouse Gas	Human Activity
Methane (CH_4)	Production of rice Landfill use Cattle/sheep ranching Creation of wetlands/bogs Leaks from pipelines, refineries, and coal mines *No credit earned for CH_4 escapes from melting permafrost because melting is not a direct result of human activity.*
Ozone (O_3)	Photochemical smog resulting from internal combustion engines, vehicle exhaust
Nitrous oxide (N_2O)	Burning of petroleum products, biomass, nitrogen-rich fuels (particularly coal) Fertilizers Feedlots (CAFO and/or CAFL) and dairy farms
CFCs (freons), HFCs, and HCFCs	Used in refrigerators and air conditioners, in foam production, to clean electronics, and formerly as propellants
Halons	Used in fire extinguishers

Greenhouse Gas Precursor	Human Activity
NO, NO_2, (NO_x)	Coal burning, internal combustion engines (fossil fuels too generic)
CO	Incomplete combustion of fossil fuels
VOCs	Gasoline/petroleum evaporation Paints and solvents Aerosols
HCs	Gasoline/petroleum • incomplete combustion • evaporation

2A,

2. According to atmospheric temperature and CO_2 concentration records derived from Antarctic ice cores, Earth's climate has undergone significant changes over the past 200,000 years. Two graphs are shown below. The upper graph shows the variation in atmospheric CO_2 concentration, and the lower graph shows the variation in air temperature. Both graphs cover the same time period from approximately 200,000 years ago up until the year 1950, which is represented as year 0 on the graphs.

TEMPERATURE AND CO_2 CONCENTRATION IN THE ATMOSPHERE OVER THE PAST 200,000 YEARS



(a) Answer the following questions that relate to the graphs above. Remember that for any calculations you must clearly indicate how you arrived at your answer. Answers must also include appropriate units.

(i) Determine the net change in atmospheric CO_2 concentration between 140,000 years ago and 125,000 years ago.

(ii) Calculate the ratio of the change in mean global temperature to the change in atmospheric CO_2 concentration between 140,000 years ago and 125,000 years ago.

(iii) Scientists predict that between 1950 and 2050, the atmospheric CO_2 concentration will increase by 200 ppm. Predict the change in mean global temperature between 1950 and 2050 using the ratio that you calculated in part (ii).

(iv) Describe one major assumption that was necessary to make the prediction in part (iii) above. Discuss the validity of the assumption.

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(b) Identify and describe TWO major causes for the predicted 200 ppm increase in atmospheric CO_2 concentration between 1950 and 2050.

(c) Identify TWO gases other than CO_2 that contribute to the anthropogenic increase in mean global temperature. For each gas, describe a major human activity that leads to its release.

a) i. CO_2 concentration at 140,000 years ago = 200 ppm
125,000 years ago = 280 ppm

$\frac{80 \text{ ppm}}{200 \text{ ppm}} = .4 = 40\%$ increase in CO_2 concentration

280 ppm − 200 ppm = 80 ppm net change in atmospheric CO_2 concentration btwn. 140,000 years ago and 125,000 years ago.

ii. Mean global Temperature at 140,000 years ago = 8°C
125,000 years ago = 2°C

2°C − (−8°C) = 10°C net change

$\frac{10°C}{80 \text{ ppm}} = \frac{1°C}{8 \text{ ppm}}$ is the ratio of the change in mean global temperature to the change in atmospheric CO_2 concentration between 140,000 years ago and 125,000 years ago.

iii. $\frac{1°C}{8 \text{ ppm}} = \frac{X°C}{200 \text{ ppm}}$

$8X = 200 \text{ ppm}$

$X = 25°C$ increase in mean global temperature

iv. A major assumption that was necessary to make

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ADDITIONAL PAGE FOR ANSWERING QUESTION 2

the prediction in part iii was that the concentration of atmospheric CO_2 and mean global temperature have a perfect linear correlation. By looking at the data for the 200,000 years before 1950 this assumption seems to be true. From this observation we can assume with some certainty that our prediction in part iii is approximately correct.

b. Two major cause for the predicted 200 ppm increase in atmospheric CO_2 are: concentration btwn. 1950 and 2050

1) Exponential growth of population meaning greater need for electricity which means more coal burning power plants in operation, which means greater release of CO_2 from coal burning.
2) Increasing population means more need for timber and more need for agricultural land thus greater deforestation especially of tropical rainforests. Reduction of forests means reduction of a major carbon sink (trees take in CO_2). Thus more atmospheric CO_2.

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

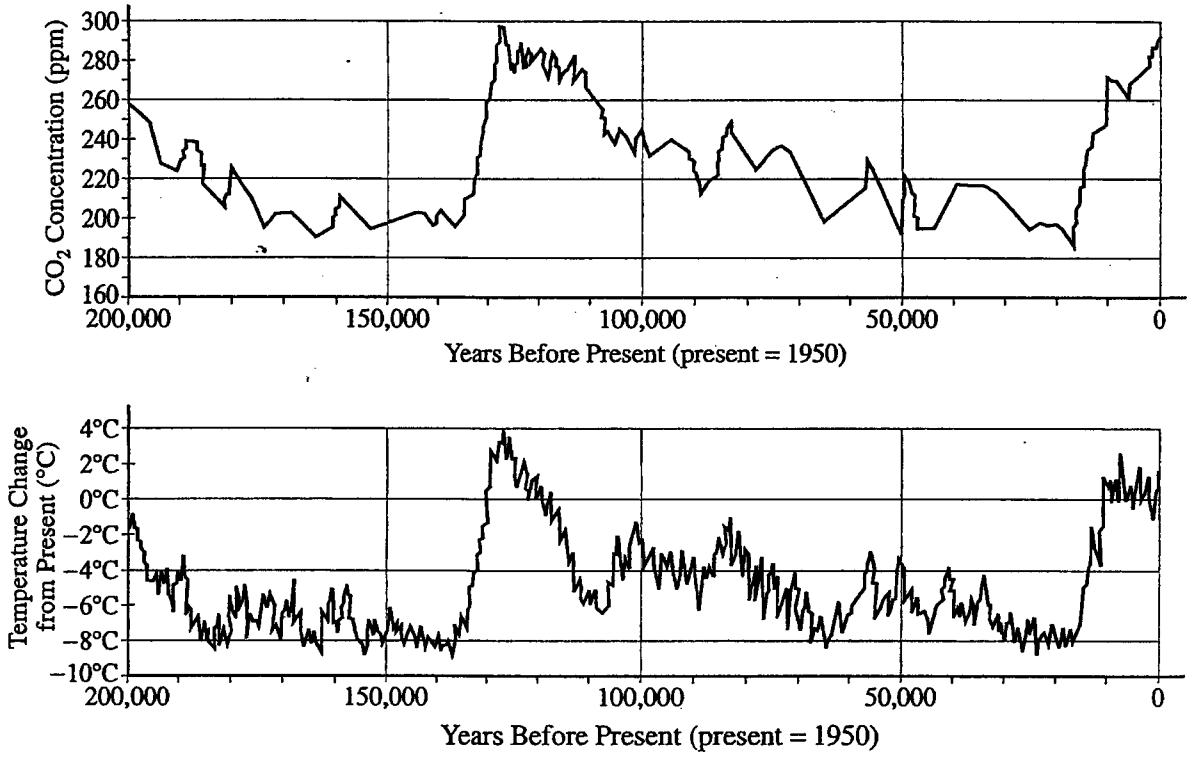
c. Two gases other than CO_2 that contribute to the anthropogenic increase in mean global temperature are:

1) Methane gas which is heavily released from ruminants especially in cattle ranches. Humans breed cattle for food so large cattle ranches and dairy farms are high releasers of methane.

2) Nitrous Oxide is another greenhouse gas. It is released from coal burning power plants. The burning of the coal releases many air pollutants including NOXs.

2. According to atmospheric temperature and CO_2 concentration records derived from Antarctic ice cores, Earth's climate has undergone significant changes over the past 200,000 years. Two graphs are shown below. The upper graph shows the variation in atmospheric CO_2 concentration, and the lower graph shows the variation in air temperature. Both graphs cover the same time period from approximately 200,000 years ago up until the year 1950, which is represented as year 0 on the graphs.

TEMPERATURE AND CO_2 CONCENTRATION IN THE ATMOSPHERE OVER THE PAST 200,000 YEARS



(a) Answer the following questions that relate to the graphs above. Remember that for any calculations you must clearly indicate how you arrived at your answer. Answers must also include appropriate units.

(i) Determine the net change in atmospheric CO_2 concentration between 140,000 years ago and 125,000 years ago.

(ii) Calculate the ratio of the change in mean global temperature to the change in atmospheric CO_2 concentration between 140,000 years ago and 125,000 years ago.

(iii) Scientists predict that between 1950 and 2050, the atmospheric CO_2 concentration will increase by 200 ppm. Predict the change in mean global temperature between 1950 and 2050 using the ratio that you calculated in part (ii).

(iv) Describe one major assumption that was necessary to make the prediction in part (iii) above. Discuss the validity of the assumption.

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(b) Identify and describe TWO major causes for the predicted 200 ppm increase in atmospheric CO_2 concentration between 1950 and 2050.

(c) Identify TWO gases other than CO_2 that contribute to the anthropogenic increase in mean global temperature. For each gas, describe a major human activity that leads to its release.

a.) (i) $280_{ppm} - 200_{ppm} = 80_{ppm}$.

(ii) $\frac{-10°C}{80ppm} = \frac{1°C}{8ppm} \Rightarrow 1°C : 8ppm$

(iii) $\frac{x}{200_{ppm}} = \frac{1°C}{8ppm}$

$8x = 200$

$x = 25°C$

(iv) The major assumption I had to make was that the ratio between 140,000 years ago and 125,000 years ago was the same ratio as the ratio between 1950 an 2050. In order for the scientist to come up with their prediction of CO_2 concentration, they also had to assume that the ratio was the same as 140,000 years ago and 125,000 years ago. Therefore, it is only logical to assume the same and have only one variable in the equation

(b) One cause for the predicted 200 ppm increase in atmospheric concentration is the increased use of fossil fuels to create energy and at the same time, emitting large ammounts of CO_2 into the air. Another cause for the predicted 200 ppm increase in atmospheric concentration could be attributed to mass ammounts of tree harvesting and deforestation in areas like the rainforest. The loss of these lands would Cause a loss of anarobic respiration, ~~the trees would not~~ their wouldn't be enough trees to handle the CO_2 and convert into oxygen, therefore causing an abundance of CO_2 in the atmosphere.

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2B3

ADDITIONAL PAGE FOR ANSWERING QUESTION 2

C.) CFC and CO both contribute to the anthropogenic increase in mean global tomprature. CFC are released through hairsprays and other things like cleavers that need propclants. CO is released when water heaters are broken

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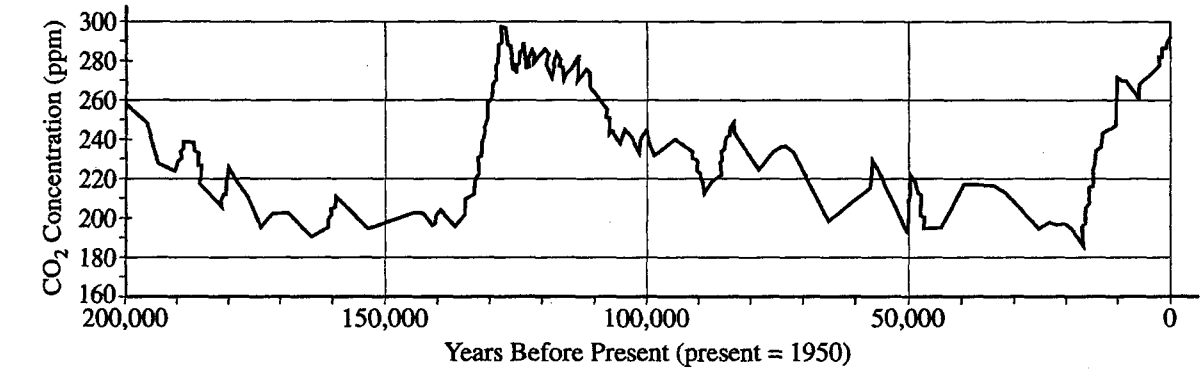
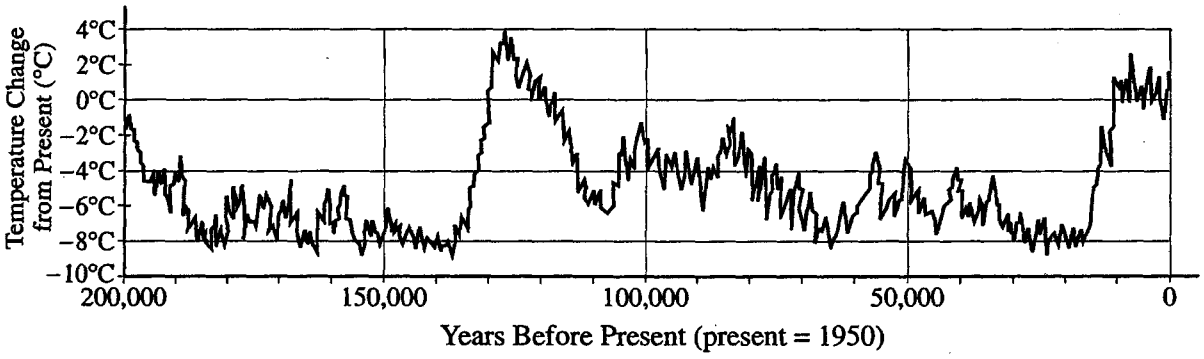
2 C,

2. According to atmospheric temperature and CO_2 concentration records derived from Antarctic ice cores, Earth's climate has undergone significant changes over the past 200,000 years. Two graphs are shown below. The upper graph shows the variation in atmospheric CO_2 concentration, and the lower graph shows the variation in air temperature. Both graphs cover the same time period from approximately 200,000 years ago up until the year 1950, which is represented as year 0 on the graphs.

TEMPERATURE AND CO_2 CONCENTRATION IN THE ATMOSPHERE OVER THE PAST 200,000 YEARS





(a) Answer the following questions that relate to the graphs above. Remember that for any calculations you must clearly indicate how you arrived at your answer. Answers must also include appropriate units.

(i) Determine the net change in atmospheric CO_2 concentration between 140,000 years ago and 125,000 years ago.

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(iii) Scientists predict that between 1950 and 2050, the atmospheric CO_2 concentration will increase by 200 ppm. Predict the change in mean global temperature between 1950 and 2050 using the ratio that you calculated in part (ii).

(iv) Describe one major assumption that was necessary to make the prediction in part (iii) above. Discuss the validity of the assumption.

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2 C_2

(b) Identify and describe TWO major causes for the predicted 200 ppm increase in atmospheric CO_2 concentration between 1950 and 2050.

(c) Identify TWO gases other than CO_2 that contribute to the anthropogenic increase in mean global temperature. For each gas, describe a major human activity that leads to its release.

a) (i) The net change in atmospheric CO_2 between 140,000 ya (years ago) 125,000 ya is about 100ppm.
(ii) The ratio of change is about 70%
(iii) The ratio is 130%
(iv) My assumtion was that has the CO_2 concentration increases so does the temperature. That is a valid assumtion because in the past years it has been true according to the graph.

b) Two major causes for the increase in atmospheric CO_2 are increasing number of people on the planet. People require energy. At the moment energy requires coal ~~fossit~~ to be burned which puts CO_2 into the atmosphere. Another cause is people drive cars and cars pollute.

c) CFC's, people release CFC's through Aersol cans.

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AP® ENVIRONMENTAL SCIENCE
2006 SCORING COMMENTARY

Question 2

Overview

This question was designed to assess students' ability to analyze data, make a prediction based on calculations using these data, and apply critical thinking skills to determine the validity of this prediction. Analysis, manipulation, and interpretation of these data provide a framework for students to view science as a process.

Sample: 2A
Score: 10

Part (a): One point was earned in (ai) for giving the correct CO_2 concentration change calculation, including units. Two points were earned in (aii): 1 point for the correct temperature change calculation, including units, and 1 point for the correct ratio calculation. One point was earned in (aiii) for the correct temperature change calculation using the ratio from above. Two points were earned in (aiv): 1 point for the assumption that there is a near-perfect correlation between temperature and CO_2 concentration, and 1 point for relating this relationship to that indicated by the graphs.

Part (b): Two points were earned: 1 point for linking growth in coal-burning power plants to an exponentially growing population, and 1 point for linking deforestation to the loss of a CO_2 sink.

Part (c): Two points were earned: 1 point for mentioning methane (linked to cattle ranches), and 1 point for saying that N_2O is emitted by coal-burning power plants.

Sample: 2B
Score: 6

Part (a): One point was earned in (ai) for giving the correct CO_2 concentration change calculation, including units. The first point in (aii) was not earned because the temperature change calculation is incorrect (-10°C). The second point in (aii) was earned for the correct ratio calculation, even though it is based on an incorrect temperature change value. One point was earned in (aiii) for the temperature change calculation. One point was earned in (aiv) for the assumption that the ratio between 140,000–125,000 years ago will be the same between 1950 and 2050. The second point was not earned because the description is only a repetition of the assumption.

Part (b): One point was earned for linking increased fossil fuel use and energy creation. The second point was not earned because the loss of the CO_2 sink caused by deforestation is incorrectly attributed to anaerobic respiration.

Part (c): One point was earned for citing CFCs, used in hairsprays and propellants. The second point was not earned because the student erroneously states that CO is released by broken water heaters.

Question 2 (continued)

Sample: 2C
Score: 4

Part (a): No point was earned in (ai) because the CO_2 concentration change is not calculated. Neither point was earned in (aii) because the temperature change and ratio are not calculated. No point was earned in (aiii) because the temperature change is not calculated. Two points were earned in (aiv): 1 point for the assumption that CO_2 and temperature changes are related, and 1 point for relating this relationship to that shown on the graphs.

Part (b): One point was earned for linking increased population and coal burning for energy production. The second point was not earned because the link between cars and pollution is too vague.

Part (c): One point was earned for stating that CFCs are released by aerosol cans. The second point was not earned because a second gas is not identified.