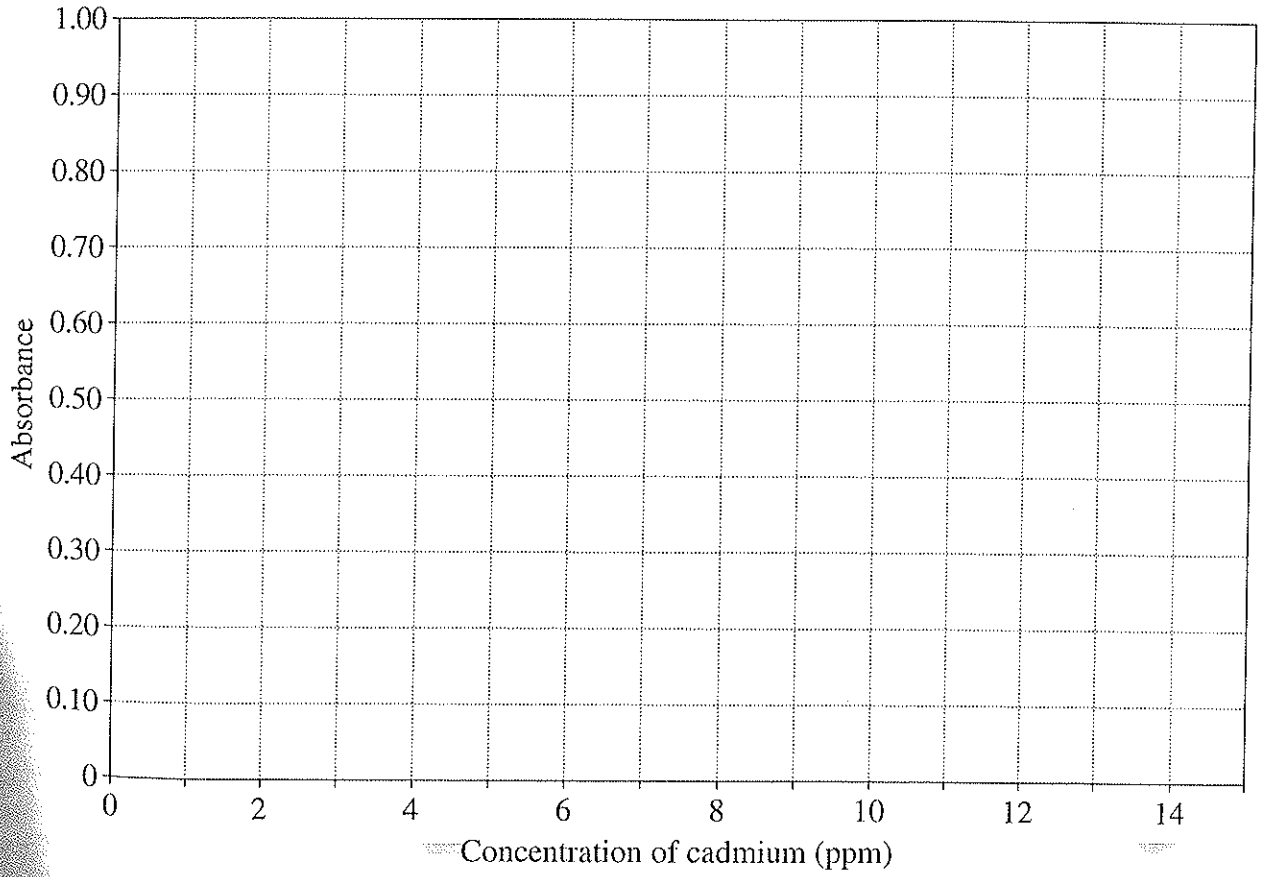
**Question 28** (4 marks) **Marks**

The results of analysis of a set of standard cadmium solutions are presented in the table.

| *Concentration of cadmium standard solution* (ppm) | *Absorbance* |
|---|---|
| 0 | 0.00 |
| 3 | 0.22 |
| 6 | 0.38 |
| 9 | 0.62 |
| 12 | 0.83 |

(a) Draw an appropriate graph of the data. **2**

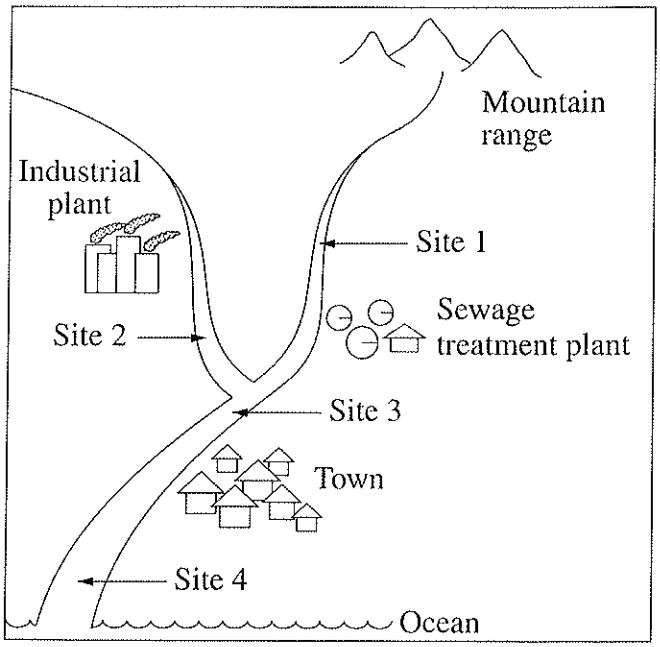



**Question 28 continues**

Marks

Question 28 (continued)

The map shows a catchment area. There is an industrial plant, a sewage treatment plant and a small town, all of which discharge water into the river. Water samples were collected at four sites.




The results of analysis of cadmium levels from these four sites are given in the table.

| *Sample site* | *Absorbance* |
|---|---|
| Site 1 | 0.08 |
| Site 2 | 0.15 |
| Site 3 | 0.55 |
| Site 4 | 0.40 |

(b) Justify your conclusion about the most likely source of cadmium pollution. **2**

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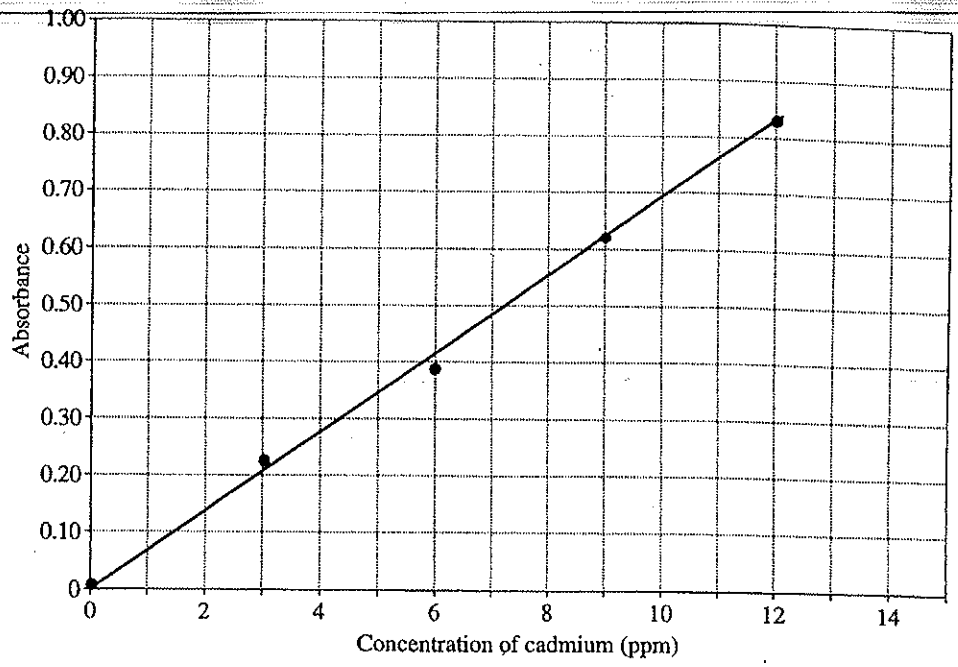
**End of Question 28**

**Marks**

**Question 29** (7 marks)

Evaluate the importance of monitoring and managing the conditions used in the Haber process. **7**

**28.** (a)




(b) The most likely source of cadmium pollution is the sewage treatment plant. The rivers flow into the ocean. Site 1 has the lowest absorbance reading (0.08) – probably due to a 'natural' background concentration. Site 2 has almost double the absorbance reading (0.15) – probably due to the industrial plant. Site 3 has the highest absorbance reading (0.55) – although this gets flows from Sites 1 and 2 and from the sewage plant, the cadmium is most likely from the sewage plant as Sites 1 and 2 show much lower levels. At Site 4, the absorbance reading (0.40) has fallen probably because of dilution effects due to tidal water movements.

**29.** The Haber process is a method of producing ammonia. It uses the reaction:

$$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$$

Under ordinary pressures and temperatures this equilibrium lies well to the left. Conditions of temperature and pressure must be monitored so that formation of ammonia occurs. A low temperature favors ammonia formation (the forward reaction is exothermic), but means the reaction is slow, whereas a high temperature means a fast reaction, but with low yield. The temperature used (about 400–500°C) is a compromise, and therefore must be monitored closely. A large pressure (about 250–400 atmospheres) favours the formation of ammonia as there are less gaseous molecules produced than react. If pressure falls, the yield of ammonia drops and the process becomes inefficient. Larger pressures also ensure faster reaction. If the pressure is too high, the reaction vessel may not withstand the pressure.

The state of the catalyst also needs monitoring. A catalyst is used to speed up the ammonia formation. If the catalyst becomes poisoned or corroded, reaction can slow markedly. Although this does not affect yield, it affects the speed at which the yield is obtained.

It is important to monitor these conditions so that ammonia can be made safely and efficiently using the Haber process.

[Note: In Australia, various industries use between 400–500°C and 250–400 atmospheres. To obtain a yield of about 30%, 525°C and 345 atmospheres are used.]