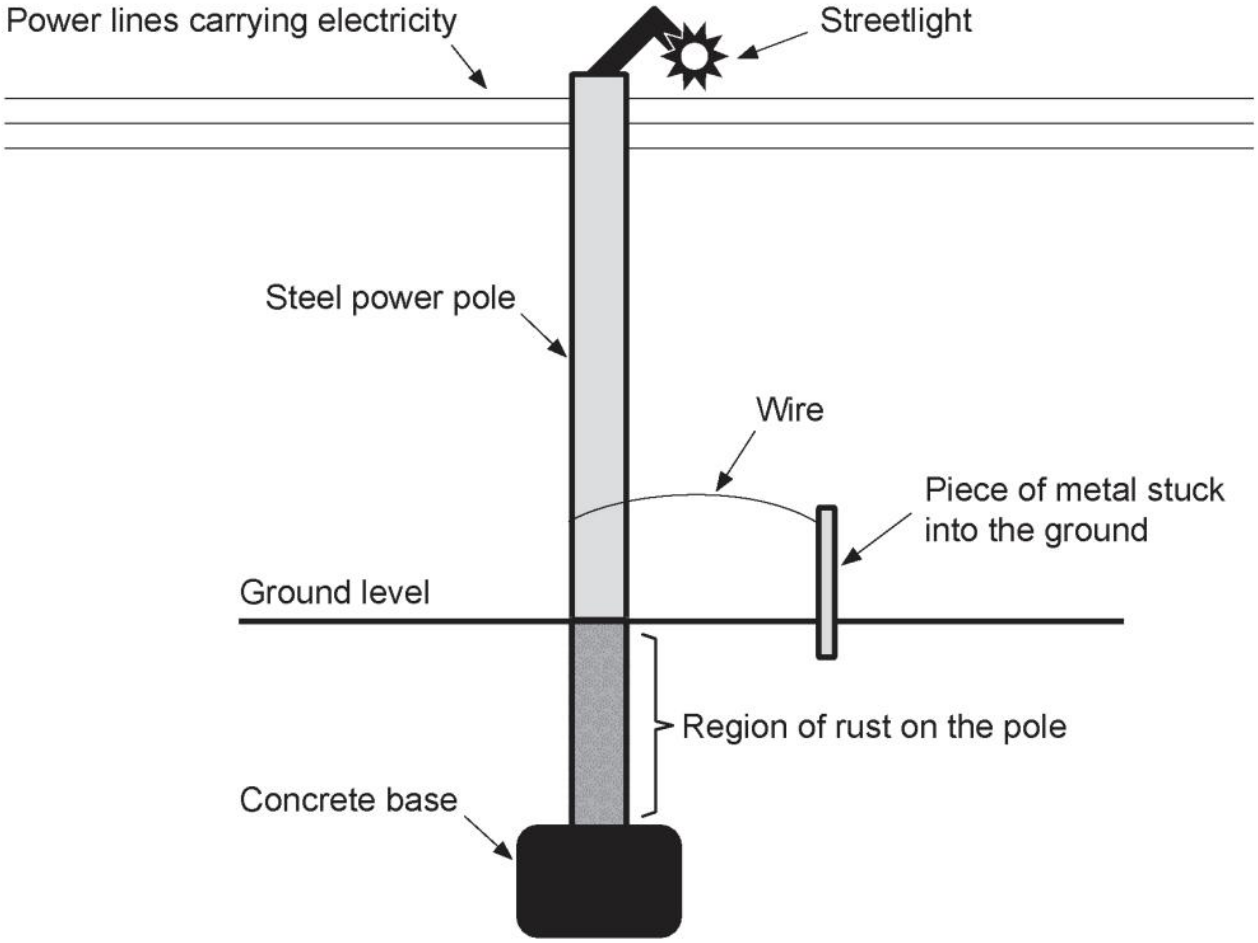
Question 39 **(17 marks)**

Steel poles are used as 'power poles' to hold streetlights and carry electricity to businesses and houses. While being stronger than timber poles and not prone to rotting, they do have the capacity to rust.



A steel pole was treated to inhibit rusting but when soil was removed at its base, significant rusting could be observed.

(a) Refer to one or more equations below, representing the various parts of the rusting process, and explain why the steel pole rusts below ground level but there were no signs of rusting above ground level. (5 marks)

Equation 1 $Fe(s) \rightarrow Fe^{2+}(aq) + 2e^-$
Equation 2 $O_2(g) + 2\ H_2O(\ell) + 4\ e^- \rightarrow 4\ OH^-(aq)$
Equation 3 $4\ Fe^{2+}(aq) + 4\ H^+(aq) + O_2(aq) \rightarrow 4\ Fe^{3+}(aq) + 2\ H_2O(\ell)$
Equation 4 $Fe^{3+}(aq) + 3\ OH^-(aq) \rightarrow Fe(OH)_3(s)$
Equation 5 $4\ Fe(OH)_2(s) + O_2(g) + x\ H_2O(\ell) \rightarrow 2\ Fe_2O_3.(x+4)H_2O(s)$

After the surrounding soil was dug away to expose the pole, two different attempts were made to protect it from rusting any further. One was to paint the pole and the other was to connect a wire from it to a piece of metal in the ground. Neither attempt was successful in preventing further rusting.

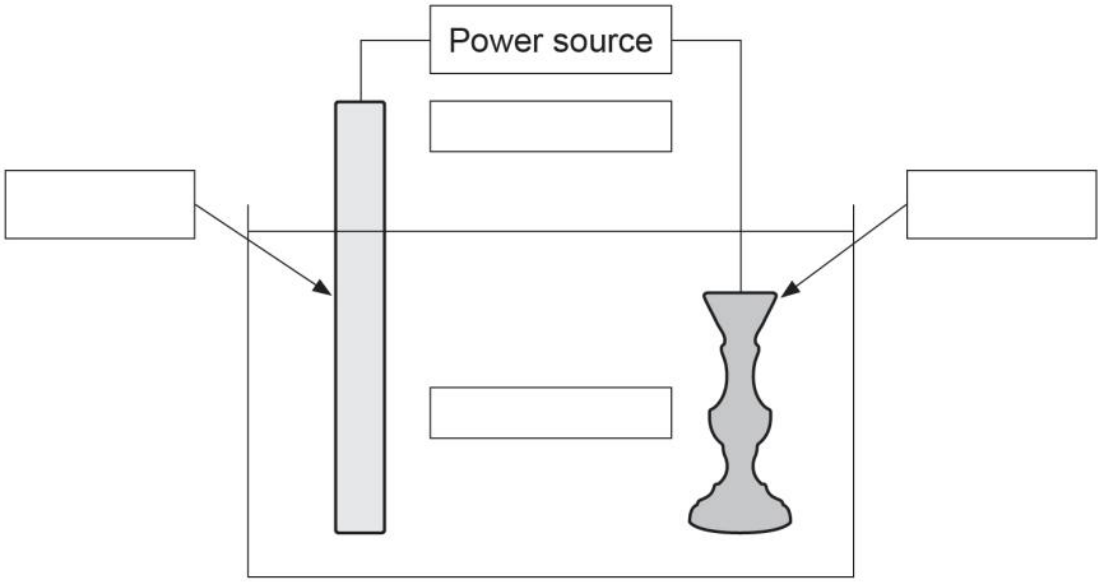
(b) Explain why these two methods did **not** work as intended. If appropriate, include an equation in your answer.

(i) Painting the pole. (2 marks)

(ii) Attaching a wire to a second metal. (3 marks)

For some iron objects, coating with a non-reactive metal is an appropriate method to reduce rusting. Electrolysis can be used to thinly coat an iron object with a metal such as chromium, a process also known as 'chrome plating'.

(c) Consider the following electrolytic cell used for the chrome plating of a candlestick. The cell consists of a lead electrode, the item to be plated and a chromium(III) chloride solution. Another chemical is added to prevent the Cr^{3+} from oxidising.



In the spaces above, label the diagram to show the:

- anode and cathode
- direction of cation flow
- direction of electron flow. (3 marks)

(d) Write ionic half-equations for the reactions occurring at the anode and the cathode. (2 marks)

Anode	
Cathode	

(e) State **two** reasons why the actual voltage required to run this cell is higher than the value that would be calculated using the standard reduction potentials. (2 marks)

One: _____

_____

Two: _____

_____