

- 4** Three characteristic properties of transition metals are complex formation, coloured ions and catalytic activity.
- 4 (a)** State the feature of transition metals that gives rise to these characteristic properties.
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- (1 mark)
- 4 (b)** State a fourth characteristic property of transition metals.
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- (1 mark)
- 4 (c)** For each of the following shapes of complex, identify an appropriate example by drawing its structure.
- 4 (c) (i)** a linear complex
- (1 mark)
- 4 (c) (ii)** a square planar complex
- (1 mark)
- 4 (c) (iii)** a tetrahedral complex
- (1 mark)

Question 4 continues on the next page

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4 (d) The chemical industry makes use of the catalytic activity of transition metal compounds. For example, vanadium(V) oxide is used as a heterogeneous catalyst in the Contact Process.

4 (d) (i) Write an equation for the overall reaction in the Contact Process.

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(1 mark)

4 (d) (ii) Explain the meaning of the term *heterogeneous* as applied to a catalyst.

.....
(1 mark)

4 (d) (iii) Write two equations to illustrate how vanadium(V) oxide acts as a catalyst in the Contact Process.

Equation 1

Equation 2
(2 marks)

4 (d) (iv) Suggest what is done to a heterogeneous catalyst such as vanadium(V) oxide to maximise its efficiency and how this is achieved.

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.....
.....
(2 marks)



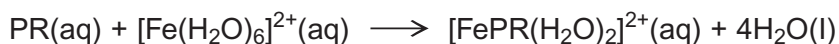
- 4 (e) The porphyrin ring is a multidentate ligand that is found in living systems complexed with iron(II) ions in haemoglobin and with cobalt(II) ions in vitamin B₁₂

- 4 (e) (i) Give the meaning of the term *multidentate*.

.....

 (1 mark)

- 4 (e) (ii) A porphyrin ring can be represented by the symbol PR. It reacts with aqueous iron(II) ions as shown in the equation below.
 The enthalpy change for this reaction is approximately zero.



Explain why the free-energy change for this reaction is negative.

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 (2 marks)

- 4 (e) (iii) In vitamin B₁₂ the cobalt(II) ion is co-ordinated to a porphyrin ring, a cyanide (CN⁻) ion and an additional unidentate ligand. The cyanide ion is very toxic.

Predict the co-ordination number of the cobalt ion in vitamin B₁₂
 Suggest why vitamin B₁₂ is **not** toxic.

Co-ordination number

Reason why vitamin B₁₂ is **not** toxic

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 (2 marks)

