Gateways School

**Transition metals**

**Revision PPQ**

51 marks

**Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_**

**Q1.**

Complexes containing transition elements have a wide variety of uses including acting as dyestuffs like *Prussian Blue*.

*Cisplatin* is a platinum-based chemotherapy drug used to treat various types of cancers. It was the first member of a class of anti-cancer drugs that react with DNA in tumour cells.

*Cisplatin* is prepared from K2PtCl4 according to the following scheme.

**All the reactions shown are reversible**.



(a)     Name the type of reaction occurring in all four steps of the scheme.

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**(1)**

(b)     Explain why an excess of potassium iodide is used in Reaction **1**.

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**(2)**

(c)     (i)      Write an equation for Reaction **1**.

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**(1)**

(ii)     Calculate the percentage atom economy for the formation of K2PtI4 in Reaction **1**.
Show your working.

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**(2)**

(d)     In Reaction **3**, silver nitrate solution is added to improve the yield of product.

(i)      Write the **simplest ionic** equation for the reaction of iodide ions with silver nitrate.

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**(1)**

(ii)     Suggest why addition of silver nitrate improves the yield of product from Reaction **3**.

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**(1)**

(e)     Suggest two reasons, other than poor practical technique, why the overall yield of *cisplatin* in this synthesis may be low.

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Reason 2 \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**(2)**

(f)     The *cisplatin* formed in Reaction **4** is impure. Outline how the impure solid is purified by recrystallisation.

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**(3)**

(g)     Platinum compounds are highly toxic.

(i)      State why *cisplatin* is used in cancer treatment despite its toxicity.

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**(1)**

(ii)     Suggest a suitable precaution that should be taken by medical staff when using *cisplatin*.

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**(1)**

**(Total 15 marks)**

**Q2.**

When iodine molecules are dissolved in aqueous solutions containing iodide ions, they react to form triiodide ions (I3–).

I2   +   I–       I3–

The reaction above between I– ions and S2O82– ions has a high activation energy and S2O82– ions are only reduced slowly to SO42– ions.
The reaction is catalysed by Fe2+ ions.

(a)     Explain why the reaction between I– ions and S2O82– ions is slow.

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**(1)**

(b)     Other than having variable oxidation states, explain why Fe2+ ions are good catalysts for this reaction.

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 **(1)**

(c)     Write a half-equation for the reduction of S2O82– ions to SO42– ions.

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**(1)**

(d)     Construct an overall equation for the reaction between S2O82– ions and I– ions.

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**(1)**

**(Total 4 marks)**

**Q3.**

The characteristic properties of transition metals include coloured ions, complex formation and catalytic activity.

(a)     Consider the chromium complexes **P** and **Q**.

|  |  |  |
| --- | --- | --- |
| [Cr(H2O)6]3+(aq)red-violet**P** |  | [Cr(H2O)5Cl]2+(aq)green**Q** |

Explain, with reference to oxidation states and electron configurations, why the chromium ions in complexes **P** and **Q** contain the same number of d electrons.
You should **not** consider the electrons donated by the ligands.

Explain, in terms of electrons, why the complexes are **different** colours.
(You are **not** required to explain why the observed colours are red-violet and green.)

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**(6)**

(b)     Write an equation to show how the [Co(NH3)6]2+(aq) ion reacts with 1,2-diaminoethane.
Explain the thermodynamic reasons why this reaction occurs.

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**(5)**

(c)     The toxic complex cisplatin is an effective anti-cancer drug because it reacts with the DNA in cancer cells, preventing cell division.

(i)      Draw the **displayed** structure of cisplatin.
On your structure, show the value of one of the bond angles at platinum.
State the charge, if any, on the complex.

**(3)**

(ii)     When cisplatin is ingested, an initial reaction involves one of the chloride ligands being replaced by water.

Write an equation for this reaction.

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**(1)**

(iii)    Suggest how the risk associated with the use of this drug can be minimised.

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**(1)**

(d)     Explain, with the aid of equations, how and why vanadium(V) oxide is used in the Contact Process.

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**(4)**

**(Total 20 marks)**

**Q4.**

A student carried out an experiment to find the mass of FeSO4.7H2O in an impure sample, **X**.
The student recorded the mass of **X**. This sample was dissolved in water and made up to 250 cm3 of solution.
The student found that, after an excess of acid had been added, 25.0 cm3 of this solution reacted with 21.3 cm3 of a 0.0150 mol dm–3 solution of K2Cr2O7

(a)    Use this information to calculate a value for the mass of FeSO4.7H2O in the sample of **X**.

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**(5)**

(b)    The student found that the calculated mass of FeSO4.7H2O was greater than the actual mass of the sample that had been weighed out. The student realised that this could be due to the nature of the impurity.

Suggest **one** property of an impurity that would cause the calculated mass of FeSO4.7H2O in **X** to be greater than the actual mass of **X**.
Explain your answer.

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**(2)**

**(Total 7 marks)**

**Q5.**

Which one of the following reactions in aqueous solution has the most positive change in entropy?

**A**       [Cu(H2O)6]2+ + 4NH3 → [Cu(NH3)4(H2O)2]2+ + 4H2O

**B**       [Cu(H2O)6]2+ + 4Cl− → [CuCl4]2− + 6H2O

**C**       [Cu(H2O)6]2+ + EDTA4− → [Cu(EDTA)]2− + 6H2O

**D**       [Cu(H2O)6]2+ + 2H2NCH2CH2NH2 → [Cu(H2NCH2CH2NH2)2(H2O)2]2+ + 4H2O

**(Total 1 mark)**

**Q6.**

The vanadium does **not** have an oxidation state of +3 in

**A**       [V(H2O)6]3+

**B**       [V(C2O4)3]3−

**C**       [V(OH)3(H2O)3]

**D**       [VCl4]3−

**(Total 1 mark)**

**Q7.**

The percentage of iron in a sample of impure iron(II) sulphate crystals can be determined by titrating solutions, made from separate weighed samples acidified with dilute sulphuric acid, against a standard solution of potassium manganate(VII).

Which one of the following would lead to an inaccurate result?

**A**       transferring the weighed sample of iron(II) sulphate into a wet conical flask

**B**       failing to measure accurately the volume of water used to dissolve each weighed sample of iron(II) sulphate

**C**       transferring the standard solution of potassium manganate(VII) from its original container to the burette using a wet beaker

**D**       failing to measure accurately the volume of dilute sulphuric acid added to the mixture before titration

**(Total 1 mark)**

**Q8.**

The percentage of iron in a sample of impure iron(II) sulphate crystals can be determined by titrating solutions, made from separate weighed samples acidified with dilute sulphuric acid, against a standard solution of potassium manganate(VII).

Which one of the following would lead to the greatest error in the calculation of the percentage of iron(II) in the sample?

**A**       an error of 0.005 g made when weighing out a sample of mass 0.987 g

**B**       an end-point error of 0.1 cm3 in 25.0 cm3

**C**       an error of 5 cm3 when measuring out 25.0 cm3 of dilute sulphuric acid

**D**       using the average of the titration values 25.4, 25.7 and 25.9 when the correct value is 25.5 cm3

**(Total 1 mark)**

**Q9.**

In the table below, which one of the following complex ions has a correct shape, co-ordination number and oxidation state?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Complex** | **Shape** | **Co-ordination number** | **Oxidation state of central cation** |
| **A** | [Ag(CN)2]− | Linear | 2 | –1 |
| **B** | [CuCl4]2− | Tetrahedral | 4 | –2 |
| **C** | [Cr(C2O4)3]3− | Octahedral | 3 | +3 |
| **D** | [Cu(NH3)4(H2O)2]2+ | Octahedral | 6 | +2 |

**(Total 1 mark)**