MEGA LECTURE

A LEVEL CHEMISTRY

TOPIC 15 – TRANSITION METALS AND COMPLEX IONS

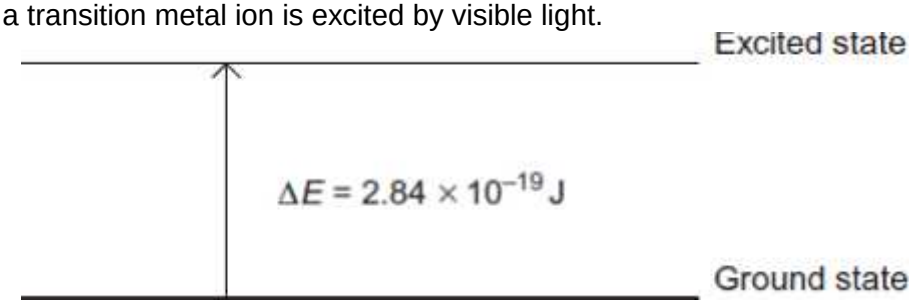
ASSESSED HOMEWORK

Answer all questions

Max 80 marks

Name ……
Mark ……../80 ……..% Grade ……

1. This diagram represents the energy change that occurs when a d electron in a transition metal ion is excited by visible light.



(a) Give the equation that relates the energy change ΔE to the Planck constant h and the frequency of the visible light v.

Use this equation and the information in the diagram to calculate a value for the frequency of the visible light, and state the units.
The Planck constant $h = 6.63 \times 10^{-34}$ J s.

Equation .....
.....

Calculation .....
.....

.....
.....

.....
.....

.....
.....

.....
.....

(2)

(b) Explain why this electron transition causes a solution containing the transition metal ion to be coloured.

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

(2)

(c) The energy change shown in the diagram represents the energy of red light and leads to a solution that appears blue.
Blue light has a higher frequency than red light.

Suggest whether the energy change ΔE will be bigger, smaller or the same for a transition metal ion that forms a red solution. Explain your answer.

Energy change .....

Explanation .....
.....

.....
.....

.....
.....

.....
.....

(2)

(d) State **three** different features of transition metal complexes that cause a change in the value of ΔE, the energy change between the ground state and the excited state of the d electrons.

Feature 1 .....

Feature 2 .....

Feature 3 .....

(3)
(Total 9 marks)

2. Due to their electron arrangements, transition metals have characteristic properties including catalytic action and the formation of complexes with different shapes.

(a) Give **two other** characteristic properties of transition metals. For each property, illustrate your answer with a transition metal of your choice.

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

(4)

(b) Other than octahedral, there are several different shapes shown by transition metal complexes. Name **three** of these shapes and for each one give the formula of a complex with that shape.

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

(6)

(c) It is possible for Group 2 metal ions to form complexes. For example, the $[Ca(H_2O)_6]^{2+}$ ion in hard water reacts with $EDTA^{4-}$ ions to form a complex ion in a similar manner to hydrated transition metal ions. This reaction can be used in a titration to measure the concentration of calcium ions in hard water.

(i) Write an equation for the equilibrium that is established when hydrated calcium ions react with $EDTA^{4-}$ ions.

.....
.....

(1)

(ii) Explain why the equilibrium in part (c)(i) is displaced almost completely to the right to form the EDTA complex.

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

(3)

(iii) In a titration, 6.25 cm^3 of a 0.0532 mol dm^{-3} solution of EDTA reacted completely with the calcium ions in a 150 cm^3 sample of a saturated solution of calcium hydroxide.
Calculate the mass of calcium hydroxide that was dissolved in 1.00 dm^3 of the calcium hydroxide solution.

.....
.....

.....
.....

.....
.....

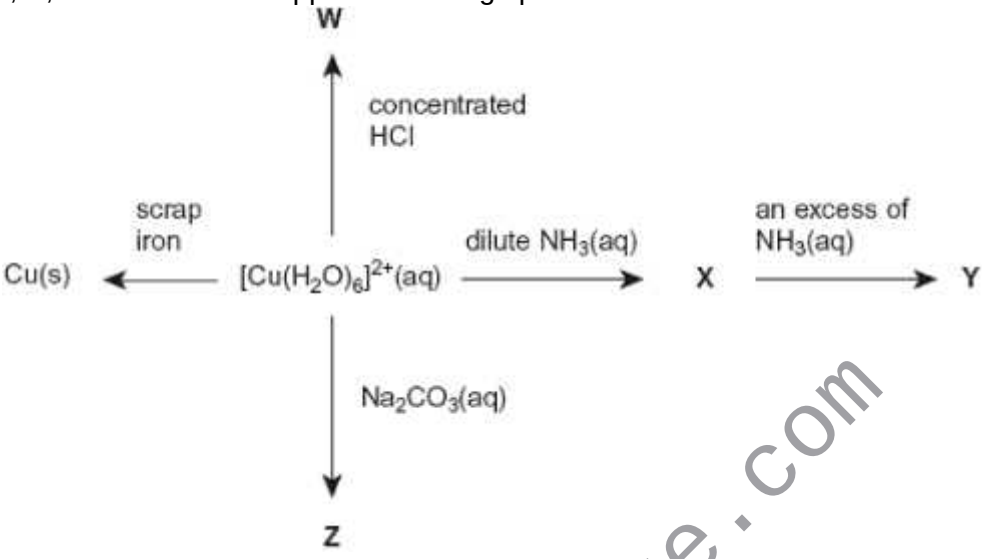
.....
.....

.....
.....

.....
.....

(3)
(Total 17 marks)

3. The scheme below shows some reactions of copper(II) ions in aqueous solution.
W, **X**, **Y** and **Z** are all copper-containing species.



(a) Identify ion **W**. Describe its appearance and write an equation for its formation from $[Cu(H_2O)_6]^{2+}(aq)$ ions.

Ion
W.....
.....

Appearance .....
.....

Equation
.....
.

(3)

(b) Identify compound **X**. Describe its appearance and write an equation for its formation from $[Cu(H_2O)_6]^{2+}(aq)$ ions.

Compound
X .....

Appearance .....
.....

Equation .....
.....

(3)

(c) Identify ion **Y**. Describe its appearance and write an equation for its formation from **X**.

Ion

Y .....
.....

Appearance .....
.....

Equation .....
.....

(3)

(d) Identify compound **Z**. Describe its appearance and write an equation for its formation from $[Cu(H_2O)_6]^{2+}(aq)$ ions.

Compound

Z .....

Appearance .....
.....

Equation .....
.....

(3)

(e) Copper metal can be extracted from a dilute aqueous solution containing copper(II) ions using scrap iron.

(i) Write an equation for this reaction and give the colours of the initial and final aqueous solutions.

Equation .....
.....

Initial

colour .....
.....

Final

colour .....
.....

(3)

(ii) This method of copper extraction uses scrap iron. Give **two** other reasons why this method of copper extraction is more

environmentally friendly than reduction of copper oxide by carbon.

Reason
1 .....
..

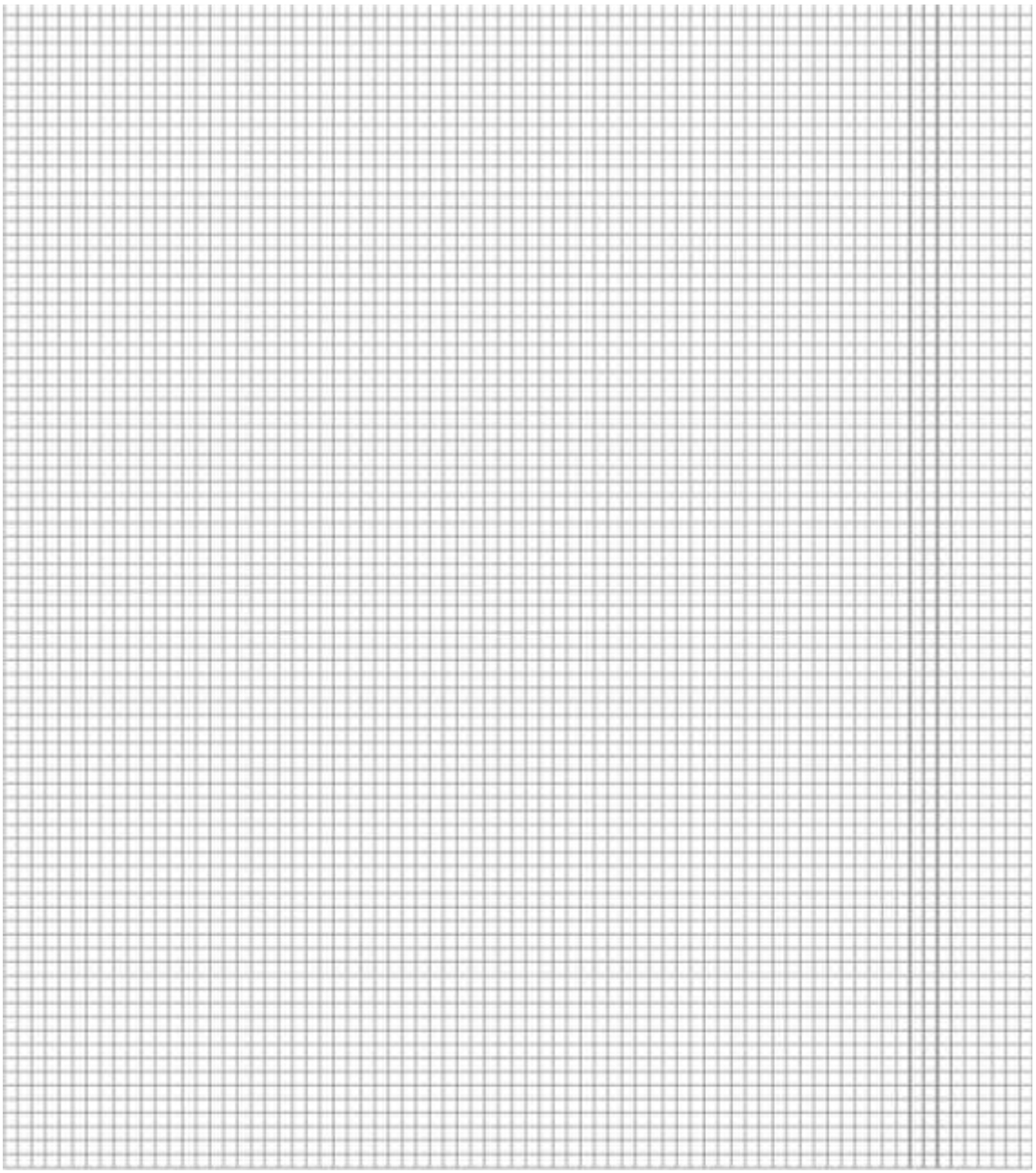
Reason
2 .....
..

(2)
(Total 17 marks)

4. (a) The concentration of iron(III) ions in a dilute solution can be determined by visible spectrometry. The absorption of light by a number of solutions of iron(III) sulfate, $Fe_2(SO_4)_3(aq)$, was measured. The results are shown in the table below.

Concentration of $Fe_2(SO_4)_3(aq)$ / mol dm^{-3}	**Absorbance / %**
0.020	2.2
0.040	4.7
0.060	7.0
0.080	9.4
0.100	11.8

(i) Use these results to plot a graph of percentage absorbance (*y*-axis) against concentration of iron(III) sulfate solution on the grid below.
Draw a straight line of best fit.



(2)

(ii) Use your graph to determine the concentration of iron(III) ions in a solution of $Fe_2(SO_4)_3$ that has an absorbance of 5.4%.

.....
.....

.....
.....

.....
.....

(2)

(iii) Calculate the volume of water that should be added to 100 cm^3 of a 0.10 mol dm^{-3} solution of iron(III) sulfate to make a 0.040 mol dm^{-3} solution.
Show your working.

.....
.....

.....
.....

.....
.....

.....
.....

(2)

(b) Give **one** reason why well-water may be more beneficial to health than pure water.

.....
.....

.....
.....

.....
.....

(1)
(Total 7 marks)

5. Transition metal ions can act as homogeneous catalysts in redox reactions. For example, iron(II) ions catalyse the reaction between peroxodisulfate ($S_2O_8^{2-}$) ions and iodide ions.

(a) State the meaning of the term *homogeneous*.

.....
.....

(1)

(b) Suggest why ions from s block elements do **not** usually act as catalysts.

.....
.....

.....
.....

(1)

(c) Write an equation for the overall reaction that occurs, in aqueous solution, between $S_2O_8^{2-}$ ions and I^- ions.

.....
.....

(1)

(d) Give **one** reason why, in the absence of a catalyst, the activation energy for the reaction between $S_2O_8^{2-}$ ions and I^- ions is high.

.....
.....

.....
.....

(1)

(e) Write two equations to show how Fe^{2+} ions can catalyse the reaction between $S_2O_8^{2-}$ ions and I^- ions. Suggest **one** reason why the activation energy for each of these reactions is low.

Equation 1 .....

Equation 2 .....

Reason .....
.....

.....

.....

(3)

(f) Explain why Fe^{3+} ions are as effective as Fe^{2+} ions in catalysing this reaction.

.....

.....

.....

.....

(1)
(Total 8 marks)

6. The redox reaction, in aqueous solution, between acidified potassium manganate(VII) and sodium ethanedioate is autocatalysed.

(a) Write an equation for this redox reaction.

Identify the species that acts as the catalyst.

Explain how the properties of the species enable it to act as a catalyst in this reaction.

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

(6)

(b) Sketch a graph to show how the concentration of MnO_4^- ions varies with time in this reaction.
Explain the shape of the graph.

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

(4)
(Total 10 marks)

7. Iron from the Blast Furnace contains carbon. In the steel-making process, oxygen is blown through molten impure iron. At stages during this process samples of iron are taken and analysed to determine the remaining carbon content. One method of analysis involves a redox titration.

At one stage a 1.27g sample of this impure iron was reacted with an excess of dilute sulphuric acid. All of the iron in the sample was converted into iron(II) sulfate, and hydrogen was evolved. The solution formed was made up to 250 cm^3. A 25.0 cm^3 sample of this solution reacted completely with exactly 19.6 cm^3 of a 0.0220 mol dm^{-1} solution of potassium manganate(VII).

(a) Write an equation for the reaction between iron and dilute sulphuric acid.

.....
.....

(1)

(b) Write an equation for the reaction of iron(II) ions with manganate(VII) ions in acid solution.

.....
.....

.....
.....

.....
.....

(1)

(c) Assuming that carbon is the only impurity, calculate the percentage by mass of carbon in the 1.27g sample.

.....
.....

.....
.....

.....
.....

.....
.....

.....
.....

(5)

(d) How would you ensure the reliability of the result obtained in this experiment?

.....
.....

(1)

(e) Suggest one way in which the reliability of this analysis could be improved.

.....
.....

(1)

(Total 9 marks)

8. Which one of the following electronic configurations is that of a transition element?

A [Ar] $4s^2 3d^{10}$

B [Ar] $4s^2 3d^9$

C [A] $4s^2 3d^0$

D [Ar] $4s^2 3d^{10} 4p^1$

(Total 1 mark)

9. A 0.0720 g sample of reducing agent **R** was dissolved in water and acidified with an excess of dilute H_2SO_4. The resulting solution was found to react with exactly 18.0 cm^3 of a 0.0200 mol dm^{-3} solution of $KMnO_4$.

In this reaction, 5 mol of **R** react with 3 mol of $KMnO_4$. The M_r of **R** is

A 120

B 167

C 240

D 333

(Total 1 mark)

10. Which of the species given below can behave as ligands?

NH_2^- NH_3 NH_4^+

A all three

B only NH_3

C NH_3 and NH_4^+

D NH_2^- and NH_3

(Total 1 mark)