



## EXAM PAPERS PRACTICE

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Level: CIE AS and A Level (9701)

Subject: Chemistry

Topic: CIE Chemistry

Type: Topic Question

2002

XVIII

1583

Chemistry CIE AS & A Level  
To be used for all exam preparation for 2025+

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# CHEMISTRY

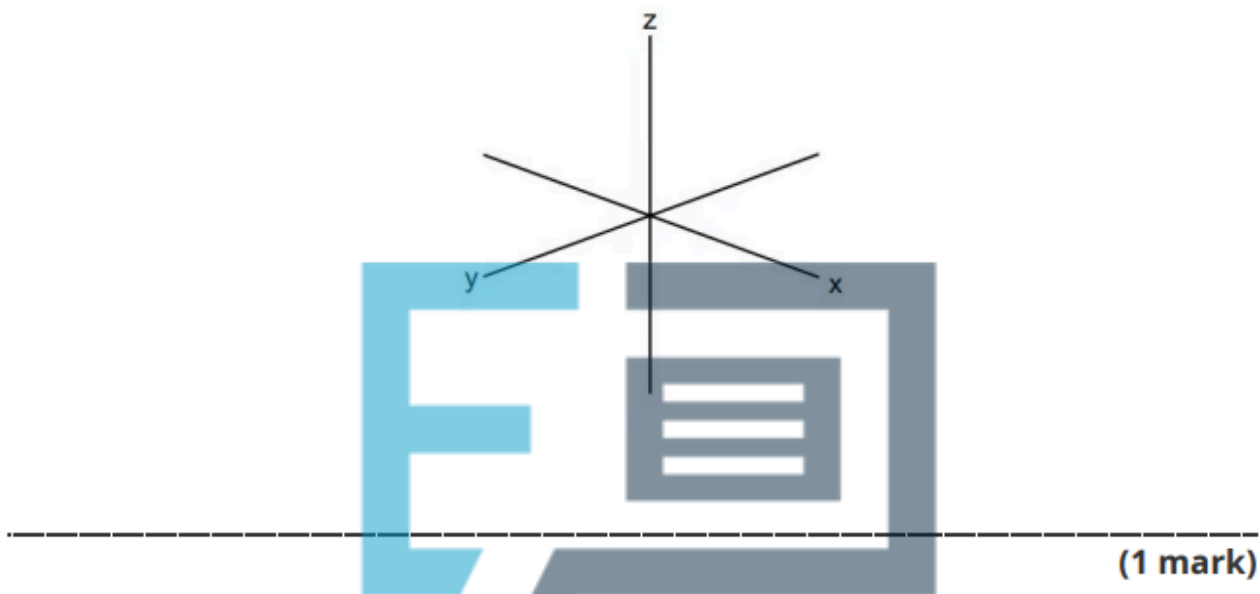
# AS and A

This to be used by all students studying CIE AS and A level Chemistry (9701) But students of other boards may find it useful

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**Question 1.**

(a) Sketch the shape of a  $3d_{xy}$  orbital.



(b) i) Some transition elements and their compounds behave as catalysts. Explain why transition elements behave as catalysts.

**EXAM PAPERS PRACTICE** [2]

ii) Catalysis can be classified as heterogeneous or homogeneous.  
 Complete Table 1.1 by placing **one** tick (✓) in each row to indicate the type of catalysis in each reaction.

**Table 1.1**

reaction	type of catalysis	
	heterogeneous	homogeneous
Fe in the Haber process		
$\text{Fe}^{2+}$ in the $\text{I}^- / \text{S}_2\text{O}_8^{2-}$ reaction		
$\text{NO}_2$ in the oxidation of $\text{SO}_2$		

[1]



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(3 marks)

- (c) A solution containing a mixture of  $\text{Sn}^{2+}(\text{aq})$  and  $\text{Sn}^{4+}(\text{aq})$  is added to a solution containing a mixture of  $\text{Fe}^{2+}(\text{aq})$  and  $\text{Fe}^{3+}(\text{aq})$ .

Table 2.2 lists electrode potentials for some electrode reactions of these ions.

Table 2.2

electrode reaction	$E^\ominus / \text{V}$
$\text{Fe}^{2+} + 2\text{e}^- = \text{Fe}$	-0.44
$\text{Fe}^{3+} + 3\text{e}^- = \text{Fe}$	-0.04
$\text{Fe}^{3+} + \text{e}^- = \text{Fe}^{2+}$	+0.77
$\text{Sn}^{2+} + 2\text{e}^- = \text{Sn}$	-0.14
$\text{Sn}^{4+} + 2\text{e}^- = \text{Sn}^{2+}$	+0.15

$E^\ominus$  data from the table can be used to predict the reaction that takes place when the two solutions are mixed.

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- i) Write an equation for this reaction.

[1]

- ii) Calculate  $E^\ominus_{\text{cell}}$  for this reaction.

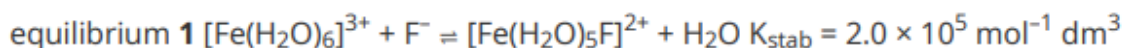
[1]

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(2 marks)

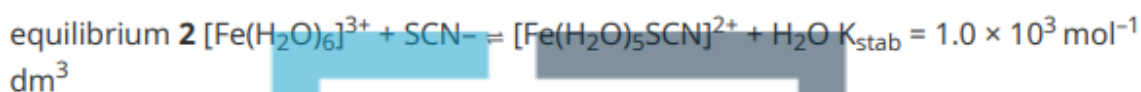


(d) Hexaaquairon(III) ions are pale violet. They form a colourless complex with fluoride ions,  $F^-$ , as shown in equilibrium **1**, and a deep-red complex with thiocyanate ions,  $SCN^-$ , as shown in equilibrium **2**.



violet

colourless



violet

deep-red

The following two experiments are carried out.

Experiment 1: A few drops of  $KSCN(aq)$  are added to  $5 \text{ cm}^3$  of  $Fe^{3+}(aq)$ , followed by a few drops of  $KF(aq)$ .

Experiment 2: A few drops of  $KF(aq)$  are added to  $5 \text{ cm}^3$  of  $Fe^{3+}(aq)$ , followed by a few drops of  $KSCN(aq)$ .

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i) Predict and explain the sequence of colour changes you would observe in each of Experiment 1 and Experiment 2.

Experiment 1 .....

Experiment 2 .....

[4]



ii) Name the type of reaction occurring during the experiments in (d)(i).

[1]

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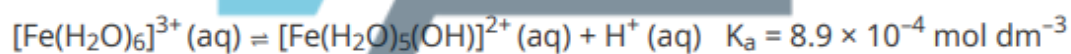
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(5 marks)

(e) Solutions of iron(III) salts are acidic due to the equilibrium shown.



Calculate the pH of a  $0.25 \text{ mol dm}^{-3}$   $\text{FeCl}_3$  solution.

Show your working.

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pH = .....

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(2 marks)

**Question 2.**

- (a) Define the term ligand.

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(1 mark)

- (b)  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$  reacts with ammonia to form a new complex. Write an expression for the overall stability constant,  $K_{\text{stab}}$ , for the formation of  $[\text{Cu}(\text{H}_2\text{O})_2(\text{NH}_3)_4]^{2+}$

$K_{\text{stab}} =$

---

(1 mark)

- (c) Table 2.1 shows the stability constants for each stage in the replacement of four water molecules for the  $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$  complex

Table 2.1

$K_n$	value / $\text{dm}^3 \text{mol}^{-1}$
$K_1$	$1.78 \times 10^4$
$K_2$	$4.07 \times 10^3$
$K_3$	$9.55 \times 10^2$
$K_4$	$1.74 \times 10^2$

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- i) Using Table 2.1, calculate the stability constant,  $K_{\text{stab}}$ , and state the units.



$K_{stab} = \dots\dots\dots$

Units =  $\dots\dots\dots$

[2]

ii) Explain how this value relates to the relative stabilities of the two complexes

[1]



(3 marks)

Question 3.

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(a) State the meaning of the term stability constant,  $K_{\text{stab}}$

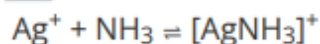
(1 mark)

(b) Silver forms different complexes. The stability constant,  $K_{\text{stab}}$ , values at 298 K are shown in Table 3.1

Table 3.1

complex	stability constant, $K_{\text{stab}}$
$[\text{Ag}(\text{CN})_2]^-$	$5.3 \times 10^{18}$
$[\text{Ag}(\text{NH}_3)]^+$	$1.7 \times 10^7$
$[\text{Ag}(\text{S}_3\text{O}_3)_2]^{3-}$	$2.9 \times 10^{13}$

The following equilibrium exists between two complex ions of silver in the +1 oxidation state.



i) Write the expression for the stability constant,  $K_{\text{stab}}$ , for this equilibrium

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[1]





- ii) When a  $0.500 \text{ mol dm}^{-3}$  solution of  $\text{AgNO}_3 \text{ (aq)}$  is mixed with  $0.500 \text{ mol dm}^{-3} \text{ NH}_3 \text{ (aq)}$  the equilibrium mixture of  $[\text{Ag}(\text{NH}_3)]^+ \text{ (aq)}$  was found to be  $0.4998 \text{ mol dm}^{-3}$

Calculate  $K_{\text{stab}}$  and state the units

$K_{\text{stab}} = \dots\dots\dots$

Units =  $\dots\dots\dots$

[3]

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(4 marks)

- (c) Using Table 3.1, deduce the order of stability of the silver complexes

most stable .....  
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.....

Copyright .....  
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least stable .....

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(1 mark)

**Question 4.**

(a) When chromium(III) sulfate dissolves in water, a green solution containing the  $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$  ion forms.

i) State the bond angles found in this complex ion.

[1]

ii) Explain why the chromium(III) complex ion is coloured.

[3]

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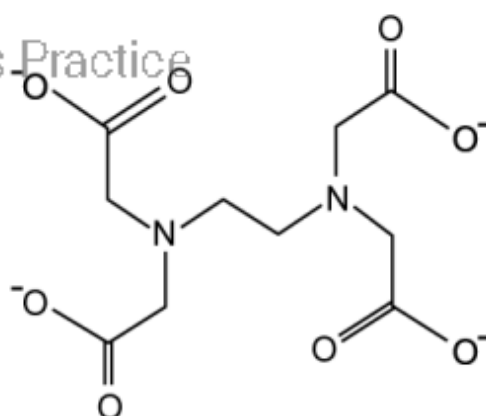
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(4 marks)

(b) Ethylenediaminetetraacetate,  $\text{EDTA}^{4-}$ , shown in Fig. 1.1, is a polydentate ligand.

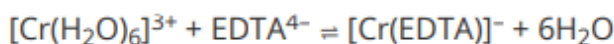
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**Fig. 1.1**

When a solution of  $\text{EDTA}^{4-}$  is added to a solution of  $[\text{Cr}(\text{H}_2\text{O})_6]^{3+}$  ions, a new complex ion is formed.



i) Name the type of reaction occurring here.

[1]

ii) Write an expression for the stability constant,  $K_{\text{stab}}$ , of  $[\text{CrEDTA}]^{-}$  in this reaction.

[1]

iii) The numerical value of the  $K_{\text{stab}}$  of  $[\text{CrEDTA}]^{-}$  is  $2.51 \times 10^{23}$  in this reaction.

Suggest what this indicates about the position and entropy of the equilibrium.

[3]

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(5 marks)

(c) Chromium (III) picolinate, shown in Fig. 1.2, is a neutral complex that can be prepared from the weak acid, picolinic acid.

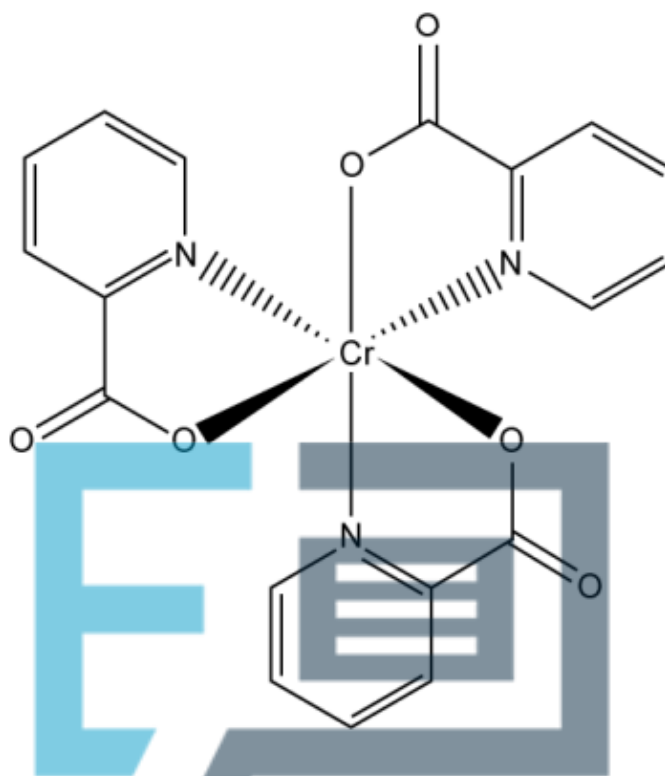


Fig. 1.2

Chromium(III) picolinate is used in tablets as a nutritional supplement for chromium.

- i) Draw the structure of the ligand in chromium(III) picolinate.

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[1]

- ii) A typical tablet of chromium(III) picolinate contains 200  $\mu\text{g}$  of chromium.

Calculate the mass, in g, of chromium (III) picolinate in a typical tablet. Give your answer to **three** significant figures.

[2]

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(3 marks)



(d) Compound **L** is a complex with the empirical formula  $\text{CrN}_4\text{H}_{12}\text{Cl}_3$

The formula of compound **L** contains one chloride ion and a complex ion **M**, which has two stereoisomers.

Complete three-dimensional diagrams to show the shape of the stereoisomers of complex ion **M**.



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(3 marks)