A-LEVEL CHEMISTRY • EXERCISE SHEET

28.4 Stereoisomerism in transition element complexes

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS stereoisomerism in complexes 配合物的立体异构 • cis 顺式 • geometrical 几何 • optical 旋光 • optical isomerism 旋光异构

Objective

Build the skills to answer exam questions on **stereoisomerism in complexes** 配合物的立体异构 — **geometrical** 几何 (cis/trans) and **optical** 旋光 isomerism, and the polarity of complexes.

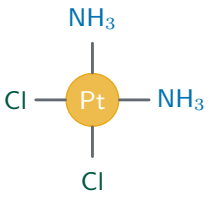
You must be able to:

- describe cis/trans isomerism in square planar and octahedral complexes
- describe optical isomerism in octahedral complexes with bidentate ligands
- deduce the overall polarity of such complexes

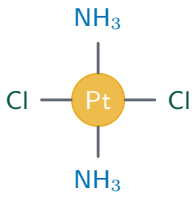
1 Worked examples

■ Geometrical and optical isomerism

square planar $[Pt(NH_3)_2Cl_2]$

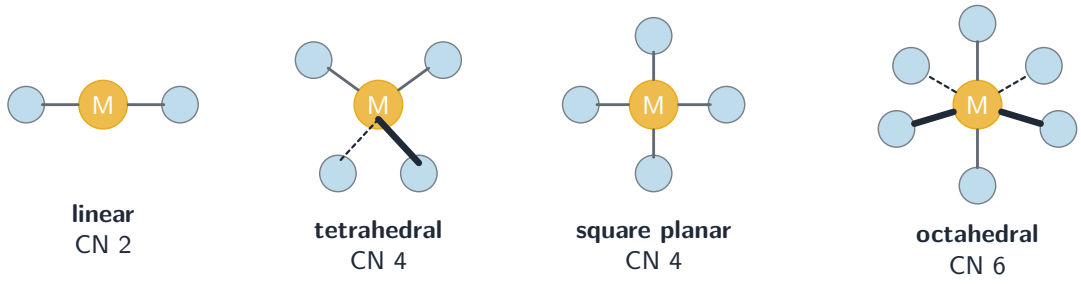


cis (same side)



trans (opposite)

Cis/trans in $[Pt(NH_3)_2Cl_2]$: the two identical ligands are adjacent (cis) or opposite (trans)



Complex shapes underlie their stereoisomerism

- **geometrical (cis/trans):** square planar (e.g. $[Pt(NH_3)_2Cl_2]$) and octahedral (e.g. $[Co(NH_3)_4(H_2O)_2]^{2+}$).
- **optical:** octahedral complexes with bidentate ligands (e.g. $[Ni(en)_3]^{2+}$) have two non-superimposable mirror images.

Polarity: a *cis* form may be polar (dipoles do not cancel); the matching *trans* form is often non-polar.

2 Practice

2.1 Name the type of stereoisomerism shown by $[Pt(NH_3)_2Cl_2]$. [1]

2.2 State what makes a complex show optical isomerism. [1]

3 Exam-style questions

3.1 Optical isomerism is shown by: [1]

- **A** $[CuCl_4]^{2-}$
- **B** $[Ni(en)_3]^{2+}$
- **C** $[Cu(H_2O)_6]^{2+}$
- **D** $[Ag(NH_3)_2]^{+}$

3.2 The *trans* isomer of a square planar complex is often: [1]

- **A** polar
- **B** non-polar (dipoles cancel)
- **C** optically active

- **D** coloured only

3.3 (a) Draw the cis and trans isomers of the square planar complex $[Pt(NH_3)_2Cl_2]$. [2]

(b) Explain why $[Ni(en)_3]^{2+}$ shows optical isomerism. [2]

3.4 State, with a reason, which of the cis or trans form of $[Pt(NH_3)_2Cl_2]$ is polar. [2]

Solutions

2.1 geometrical (cis/trans) isomerism.

2.2 it has two non-superimposable mirror images (e.g. an octahedral complex with bidentate ligands).

3.1 B. $[Ni(en)_3]^{2+}$ (octahedral with three bidentate ligands) shows optical isomerism.

3.2 B. In the trans form the dipoles cancel, so it is non-polar.

3.3 (a) cis — the two NH_3 (and two Cl) adjacent; trans — the two NH_3 (and two Cl) opposite.
(b) it is octahedral with three bidentate (en) ligands, giving two non-superimposable mirror images (enantiomers).

3.4 the cis form is polar; its two Pt–Cl dipoles are on the same side and do not cancel, while in the trans form they are opposite and cancel.