Exercise walk-through

Stereoisomerism in transition element complexes ▪ 28.4

eXercise

You must be able to

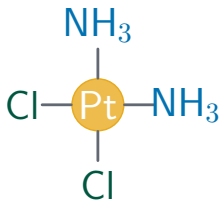
- describe cis/trans isomerism in square planar and octahedral complexes
- describe optical isomerism in octahedral complexes with bidentate ligands
- deduce the overall polarity of such complexes

Method — Geometrical and optical isomerism

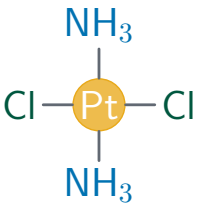
- **geometrical (cis/trans):** square planar (e.g. $[Pt(NH_3)_2Cl_2]$) and octahedral (e.g. $[Co(NH_3)_4(H_2O)_2]^{2+}$).
- **optical:** octahedral complexes with bidentate ligands (e.g. $[Ni(en)_3]^{2+}$) have two non-superimposable mirror images.

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

square planar $[Pt(NH_3)_2Cl_2]$



cis (same side)

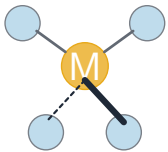


trans (opposite)

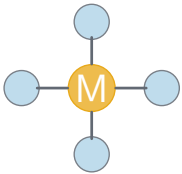
A square planar Pt complex drawn cis (the two NH adjacent) and trans (opposite)

Method — Geometrical and optical isomerism

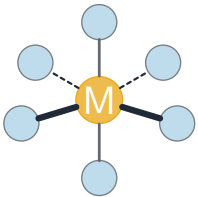
linear
CN 2



tetrahedral
CN 4



square planar
CN 4



octahedral
CN 6

Complex shapes underlie their stereoisomerism

Practice 2.1 ▪ 1 mark

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

Solution 2.1

Method: Geometrical and optical isomerism

Worked steps

geometrical (cis/trans) isomerism B1.

Practice 2.2 ▪ 1 mark

State what makes a complex show optical isomerism.

Solution 2.2

Method: Geometrical and optical isomerism

Worked steps

it has two non-superimposable mirror images (e.g. an octahedral complex with bidentate ligands) B1.

Exam-style 3.1 ▪ 1 mark

Optical isomerism is shown by:

A $[CuCl_4]^{2-}$

B $[Ni(en)_3]^{2+}$

C $[Cu(H_2O)_6]^{2+}$

D $[Ag(NH_3)_2]^{+}$

Solution 3.1

Method: Geometrical and optical isomerism

A $[CuCl_4]^{2-}$

B $[Ni(en)_3]^{2+}$ ✓

C $[Cu(H_2O)_6]^{2+}$

D $[Ag(NH_3)_2]^{+}$

Worked steps

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

Exam-style 3.2 ▪ 1 mark

The *trans* isomer of a square planar complex is often:

A polar

B non-polar (dipoles cancel)

C optically active

D coloured only

Solution 3.2

Method: Geometrical and optical isomerism

A polar

B non-polar (dipoles cancel) ✓

C optically active

D coloured only

Worked steps

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

Exam-style 3.3 ▪ 2 marks

(a) Draw the cis and trans isomers of the square planar complex $[Pt(NH_3)_2Cl_2]$.
(b) Explain why $[Ni(en)_3]^{2+}$ shows optical isomerism.

Solution 3.3

Method: Geometrical and optical isomerism

Worked steps

(a) cis — the two NH (and two Cl) adjacent; trans — the two NH (and two Cl) opposite **M1** *each correct*.
(b) it is octahedral with three bidentate (en) ligands, giving two non-superimposable mirror images (enantiomers) **M1** **A1**.

Exam-style 3.4 ▪ 2 marks

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

Solution 3.4

Method: Geometrical and optical isomerism

Worked steps

the cis form is polar **M1**; its two Pt–Cl dipoles are on the same side and do not cancel, while in the trans form they are opposite and cancel **A1**.