

Colour, complexes and catalysis in the d-block

Chemistry grades 11-12 (A Level · IB · Class 11-12) · Lab answers

These model answers use the sample table. Colours and the through-origin gradient should match closely; expect your own absorbances to differ slightly, but the straight-line pattern must be clear.

Level: Chemistry grades 11-12 (A Level · IB · Class 11-12) · **Curriculum:** A Level 3.2.5

Question 1 Colour changes

Tube 1: $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$; tube 3: $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+}$; tube 4: $[\text{CuCl}_4]^{2-}$.

Question 2 Equations

Tube 2: $\text{Cu}^{2+}(\text{aq}) + 2\text{OH}^{-}(\text{aq}) \rightarrow \text{Cu}(\text{OH})_2(\text{s})$ (ammonia gives OH^{-}). Tube 3: $[\text{Cu}(\text{H}_2\text{O})_6]^{2+} + 4\text{NH}_3 \rightarrow [\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]^{2+} + 4\text{H}_2\text{O}$.

Question 3 Explain the change in tube 4

Chloride ions are bigger than water molecules, so only **four chloride ligands fit**, giving tetrahedral $[\text{CuCl}_4]^{2-}$. Water shifts the equilibrium back toward $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$, which is blue.

Question 4 Calibration graph

The points lie close to a **straight line through the origin**, showing absorbance is directly proportional to concentration (Beer-Lambert behaviour).

Question 5 Molar absorptivity

Slope = $\Sigma(\text{Ac}) \div \Sigma c^2 = 0.0898 \div 0.012 = \mathbf{7.5 \text{ dm}^3 \text{ mol}^{-1}}$; it measures how strongly the complex absorbs at 600 nm for a 1 cm cell.

Question 6 Unknown solution

$c = 0.36 \div 7.5 = \mathbf{0.048 \text{ mol dm}^{-3}}$ for the diluted sample; the dilution was $\times 5$, so the original is $\mathbf{0.24 \text{ mol dm}^{-3}}$.

Question 7 Why a filter

The complex absorbs orange-red light most strongly, so the filter picks the wavelength with the **greatest absorbance** for a sensitive reading.

Question 8 Improvements

Use a volumetric pipette and flask for the dilutions, and repeat each absorbance reading three times and average them. **Zero the colorimeter** with a water blank each time.