Answer all the questions below as fully as you can then check your answers

1. Which of the following transition metal compounds is commonly used to produce blue glass and ceramics?

a) Chromium oxide b) Cobalt oxide c) Iron(III) oxide

d) Vanadium oxide

2. The colour of a transition metal complex is NOT affected by:

a) The metal ion present

b) The number of neutrons in the metal ion's nucleus

c) The oxidation state of the metal ion

d) The ligands bonded to the metal ion

3. What causes the splitting of d-orbitals in transition metal complexes?

a) Repulsion between d-electrons and the nucleus

b) Repulsion between d-electrons and ligand electrons

c) Attraction between d-electrons and ligand nuclei

d) Attraction between d-electrons and the nucleus

3. Which of the following ligands is considered a "strong field" ligand?

a) Cl^- b) H_2O c) CN^- d) F^-

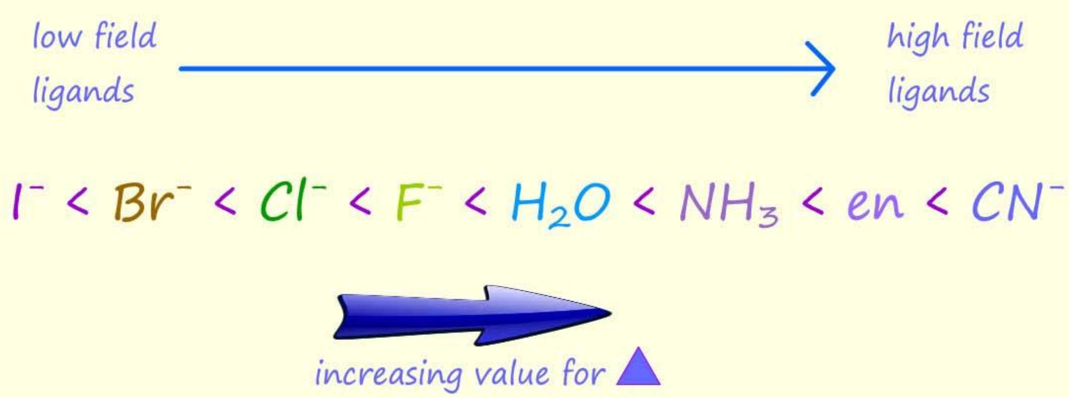
4. Explain why changing the oxidation state of a transition metal ion often results in a colour change in its complexes.

5. Describe the difference in d-orbital splitting between octahedral and tetrahedral complexes.

6. Explain why $[Fe(H_2O)_6]^{2+}$ is a different colour to $[Fe(H_2O)_6]^{3+}$.

7. A solution of $[Cu(H_2O)_6]^{2+}$ is blue. When concentrated HCl is added, the solution turns green and the tetrahedral complex $[CuCl_4]^{2-}$ forms. Explain why there is a colour change in this reaction.

8. The complex $[Ni(NH_3)_6]^{2+}$ is violet, while $[Ni(H_2O)_6]^{2+}$ is green. Explain this difference in colour using the spectrochemical series.



9. A transition metal complex absorbs light with a wavelength of 500 nm. Calculate the crystal field splitting energy (Δ) in kJ mol^{-1} using the formula below:

Planck's constant= 6.63×10^{-34} Js

Velocity of light= 3.00×10^{8} m/s

crystal field splitting energy(Δ)

$$\Delta = h\nu = \frac{hc}{\lambda}$$

λ = wavelength
ν = frequency
c=speed of light

Answers

1. Which of the following transition metal compounds is commonly used to produce blue glass and ceramics?

a) Chromium oxide b) Cobalt oxide c) Iron(III) oxide d) Vanadium oxide

Answer: b)

2. The colour of a transition metal complex is NOT affected by:

a) The metal ion present

b) The number of neutrons in the metal ion's nucleus

c) The oxidation state of the metal ion

d) The ligands bonded to the metal ion

Answer: b)

3. What causes the splitting of d-orbitals in transition metal complexes?

a) Repulsion between d-electrons and the nucleus

b) Repulsion between d-electrons and ligand electrons

c) Attraction between d-electrons and ligand nuclei

d) Attraction between d-electrons and the nucleus

Answer: b)

3. Which of the following ligands is considered a "strong field" ligand?

a) Cl^- b) H_2O c) CN^- d) F^-

Answer: c)

4. Explain why changing the oxidation state of a transition metal ion often results in a colour change in its complexes.

Answer: Changing the oxidation state alters the number of d-electrons and the electronic arrangement and thus the energy difference between the split d orbitals in the metal ion. This affects the magnitude of the crystal field splitting energy (Δ), which in turn changes the energy (and therefore wavelength) of light absorbed, leading to a different observed colour.

5. Describe the difference in d-orbital splitting between octahedral and tetrahedral complexes.

Answer: In octahedral complexes, the dx^2-y^2 and dz^2 orbitals are higher in energy than the dxy, dxz, and dyz orbitals. In tetrahedral complexes, the splitting is reversed, with the dxy, dxz, and dyz orbitals being higher in energy. The magnitude of splitting is also smaller in tetrahedral complexes.

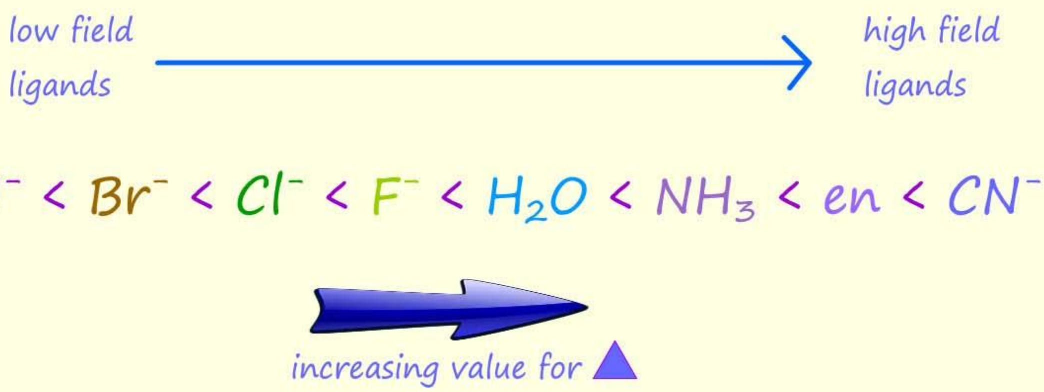
6. Explain why $[Fe(H_2O)_6]^{2+}$ is a different colour to $[Fe(H_2O)_6]^{3+}$.

Answer: The iron ion changes oxidation state from +2 in $[Fe(H_2O)_6]^{2+}$ to +3 in $[Fe(H_2O)_6]^{3+}$. This change in oxidation state alters the number of d electrons present in the central metal ion, altering electron configuration and thus the energy difference between the split d orbitals. This results in the absorption of different wavelengths of light, leading to the observed colour change.

7. A solution of $[Cu(H_2O)_6]^{2+}$ is blue. When concentrated HCl is added, the solution turns green and the tetrahedral complex $[CuCl_4]^{2-}$ forms. Explain why there is a colour change in this reaction.

Answer: The addition of concentrated HCl introduces Cl^- ions, which act as ligands. These Cl^- ions replace the water ligands to form $[CuCl_4]^{2-}$. The geometry changes from octahedral ($[Cu(H_2O)_6]^{2+}$) to tetrahedral ($[CuCl_4]^{2-}$). This change in geometry and ligand alters the crystal field splitting, resulting in the absorption of different wavelengths of light and thus a colour change from blue to green.

8. The complex $[Ni(NH_3)_6]^{2+}$ is violet, while $[Ni(H_2O)_6]^{2+}$ is green. Explain this difference in colour using the spectrochemical series.



Answer: Ammonia (NH_3) is a stronger field ligand than water (H_2O). This means that NH_3 causes a larger splitting of the d-orbitals (larger Δ) compared to H_2O. A larger Δ corresponds to the absorption of higher energy (shorter wavelength) light. Since violet light has a shorter wavelength than green light, the complex with the stronger field ligand (NH_3) absorbs higher energy light and appears violet, while the complex with the weaker field ligand (H_2O) absorbs lower energy light and appears green.

9. A transition metal complex absorbs light with a wavelength of 500 nm. Calculate the crystal field splitting energy (Δ) in kJ mol^{-1} using the formula below:

Planck's constant= 6.63×10^{-34} Js

Velocity of light= 3.00×10^{8} m/s

crystal field splitting energy(Δ)

$$\Delta = h\nu = \frac{hc}{\lambda}$$

λ = wavelength
ν = frequency
c=speed of light

Answer:

$E = hc/\lambda$

$E = (6.63 \times 10^{-34}\ Js)(3.00 \times 10^{8}\ m\ s^{-1})/(500 \times 10^{-9}\ m) = 3.98 \times 10^{-19}\ J$

Δ (per mole) $= (3.98 \times 10^{-19}\ J) \times (6.02 \times 10^{23}\ mol^{-1}) = 239.6\ kJ\ mol^{-1}$