

- 5 (a) Copper shows typical properties of transition elements, including its behaviour as a catalyst.

Complete Table 5.1 to show the total number of **unpaired** electrons in the 3d and 4s orbitals of an isolated gaseous Cu atom and a Cu²⁺ ion.

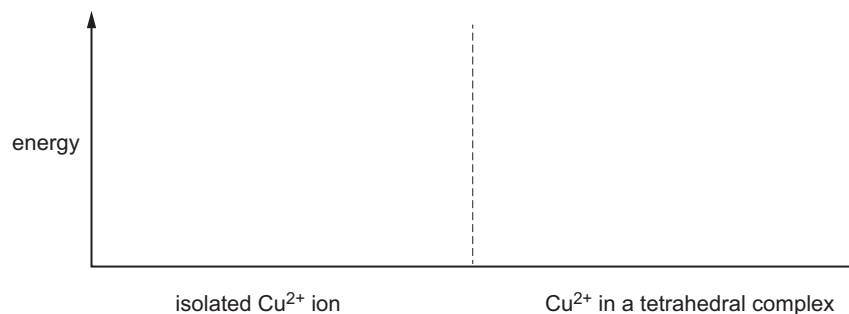
Table 5.1

species	number of unpaired electrons	
	3d	4s
Cu		
Cu ²⁺		

[1]

- (b) The 3d orbitals in an isolated Cu²⁺ ion are degenerate.

Complete the diagram to show the relative energies of the 3d orbitals in an isolated Cu²⁺ ion and in Cu²⁺ in a tetrahedral complex.



[2]

- (c) Explain why transition elements behave as catalysts.

.....

 [2]

- (d) CN⁻ is a monodentate ligand.

Table 5.2 shows information about two complex ions that contain only CN⁻ ions as ligands.

Complete Table 5.2.

Table 5.2

metal ion	coordination number	formula of complex ion	charge of complex ion
Ag ⁺	2		
Fe ²⁺			4-

[2]

- (e) The complex ion [Au(CN)₂Br₂]⁻ displays geometrical (cis/trans) isomerism.

Draw the structure of *trans*-[Au(CN)₂Br₂]⁻. State its shape and the Br-Au-Br bond angle.

shape

Br-Au-Br bond angle = [2]

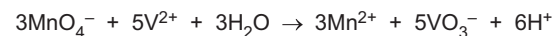
- (f) An impure sample of a vanadium(V) compound of mass 0.250 g is dissolved in aqueous acid. This solution contains VO_3^- ions.

An excess of zinc is added to this solution. All the VO_3^- ions are reduced to V^{2+} ions and Zn atoms are oxidised to Zn^{2+} ions.

The unreacted zinc is removed and the resulting solution is titrated with acidified MnO_4^- .

The end-point is reached when 22.5 cm^3 of $0.0750\text{ mol dm}^{-3}\text{ MnO}_4^-$ is added.

A redox reaction takes place and all the V^{2+} reacts forming VO_3^- .



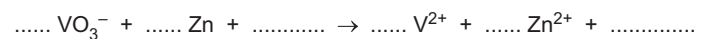
- (i) Calculate the percentage by mass of vanadium in the 0.250 g of impure sample.

Assume the impurities do not contain any vanadium ions.

Show your working.

percentage of vanadium = [3]

- (ii) Complete the equation for the reaction between acidified VO_3^- ions and Zn metal.



[2]

[Total: 14]