

BINDURA UNIVERSITY OF SCIENCE EDUCATION

CHEMISTRY DEPARTMENT

DIPLOMA IN SCIENCE EDUCATION

OCT 2022

COURSE: DCH008 TRANSITION METAL CHEMISTRY

2 HOURS

ANSWER QUESTION 1 AND FOUR (4) OTHER QUESTIONS TWO (2) FROM EACH OF THE SECTIONS "A" AND "B". EACH QUESTION CARRIES 20 MARKS

1. (a) (i) Define charge density. [2 marks]
- (ii) Explain the difference in density between s-block elements and d-block elements. [3 marks]
- (b) Study the data below and answer questions that follow

Element	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn
Melting point/°C	1541	1668	1910	1907	1246	1538	1495	1455	1084	419

- (i) Why is it that Cr has the highest number of unpaired electrons but its melting point is lower than V? [2 marks]
- (ii) Why does Mn have an exceptionally low melting point? [1 mark]
- (c) Draw the structure of MnO_4^- . [4 marks]
- (d) Fill in the missing information in the table below

Ion	Oxidation state	Colour
V^{2+}	+2	Violet
V^{3+}	+3	
VO^{2+}		Blue
VO_2^+		

[4 marks]

- (e) When aluminium reacts with chlorine and hydrogen chloride respectively, aluminium chloride (AlCl_3) is formed in both cases. However, two different products are produced when iron reacts with these two chemicals respectively. Explain. [4 marks]

SECTION A : ANSWER TWO QUESTIONS FROM THIS SECTION

2. (a) Draw the structure of ethylenediamine indicating which elements are involved in binding with the central metal ion. [4 marks]
- (b) Name the following chromium complexes:
- (i) $[\text{CrCl}_2(\text{OH}_2)_4]^+$ [3 marks]
- (ii) $[\text{Cr}(\text{OH}_2)(\text{NH}_3)_5]^{3+}$ [3 marks]
- (c) Write formulae for the following complexes:
- (i) Tetraamminechloronitrocobalt (II) ion
- (ii) Pentaquabromomanganese(III) sulfate [2×3 marks]
- (d) Determine the oxidation number for each of the transition metal atoms or ions:
- (i) $[\text{V}(\text{OH}_2)_6](\text{NO}_3)_3$
- (ii) $(\text{NH}_4)_2[\text{CoCl}_4]$ [2 × 2 marks]
3. Describe the trend of the following across the first row transition metal series:
- (a) Atomic radii [6 marks]
- (b) Density [4 marks]
- (c) Ionization enthalpy [5 marks]
- (d) electronegativity [5 marks]
4. (a) Explain what the stereochemistry of the complex means. [2 marks]
- (b) What determines the coordination number of the central metal atom or ion ? [4 marks]
- (c) Draw structure of :
- (i) A homoleptic tetrahedral complex. [4 marks]
- (ii) A heteroleptic tetrahedral complex. [4 marks]
- (d) Draw *fac* and *mer*- $[\text{Fe}(\text{CN})_3(\text{Br})_3]^{4-}$. [6 marks]

SECTION B : ANSWER TWO QUESTIONS FROM THIS SECTION

5. (a) Why is Ti^{4+} colourless? [5 marks]
- (b) Illustrate the splitting of the degenerate 3d orbitals of a d-block metal ion in an octahedral complex. [5 marks]
- (c) Use orbital diagrams to show the difference between d_z^2 and d_{xz} . [6 marks]
- (c) What determines ΔE for orbitals in octahedral environment? [4 marks]

6. (a) When 0.5 M CuSO_4 solution is put into a test tube, the complex ion present is $[\text{Cu}(\text{H}_2\text{O})_4]^{2+}$ which is pale blue. When conc. HCl is added dropwise to the CuSO_4 solution, the solution turns from pale blue to green and finally to yellow. This is due to the stepwise replacement of a weaker ligand by a stronger ligand. Each stage is characterized by an equilibrium constant called the stepwise stability constant.
- (i) State which ligand is weaker and which ligand is stronger? [2 marks]
- (ii) Write the overall equation and the expression for the overall stability constant. [6 marks]
- (b) The stepwise stability constant for the formation of $[\text{CuCl}_4]^{2-}(\text{aq})$ decreases from K_1 to K_4 as each H_2O ligand is removed. What are the possible reasons? [6 marks]
- (c) Use labelled structures to distinguish between haemoglobin and oxyhaemoglobin. [6 marks]
7. (a) Draw the structure for each of the following complex compounds or ions:
- (i) *trans*-dichlorobis(ethylenediamine)cobalt (III) ion [3 marks]
- (ii) *cis*-diammine-*trans*-dibromo-*cis*-dichloroplatinum (VI) bromide [3 marks]
- (iii) both optical isomers for *cis*-aqua-*cis*-carbonyl-*cis*-cyanonickel (II). [6 marks]
- (b) Put the following compounds together to give the formula of the compound. Remember to use [] to identify the complex ion in ionic complexes. Where you need a counterion to produce a neutral compound, use either K^+ or SO_4^{2-} .
- (i) Co^{2+} and Four Br^-
- (ii) Ni^{+2} and Two Br^- , two NH_3 , and two CN^- .
- [2×4 marks]

END OF PAPER