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WORKSHEET 10

School: Ba Sangam College

Year: 13

Subject: Chemistry

Name: _____

Strand	4 - Materials
Sub strand	4.1- Inorganic Chemistry
Content Learning Outcome	-Describe some properties of transition metals. -Explain the occurrence of coloured compounds. -Describe the use of transition metals as catalyst.

2. Transition metals as coloured compounds

- Transition metals are able to form coloured compounds because of the electrons in the incompletely filled d subshells.
- transition metals or their ions exist as coloured compounds because they are able to absorb and re-emit light of different wavelengths.
- Transition metal ions that do not have partially filled d orbitals are not coloured. An example is Sc^{3+} .

Note: When the ligands around a particular metal ion is changed, the colour of the metal ion changes. This is because the difference in energy between the 'd' subshell changes, thus changing the colour.			
Example: Colour of the different complexes of copper ion (Cu^{2+})			
Name	Tetraaqua copper(II) ion	Tetraamminecopper(II) ion	
Formula of Complex	$[\text{Cu}(\text{H}_2\text{O})_4]^{2+}(\text{aq})$	$[\text{Cu}(\text{NH}_3)_4]^{2+}(\text{aq})$	
Colour	Light blue	Dark blue	

The colours of some common oxidation states of the transition metals is shown in the table below.

Transition Metal	Symbol of the Ion	Oxidation state	Colour
Scandium	Sc^{3+}	+3	Colourless
Titanium	Ti^{3+}	+3	Violet
	Ti^{4+}	+4	Colourless
Vanadium	V^{2+}	+2	Violet
	V^{3+}	+3	Green
	V^{4+}	+4	Blue
	V^{5+}	+5	Yellow
Chromium	Cr^{2+}	+2	Blue
	Cr^{3+}	+3	Green
	Cr^{6+}	+6	Yellow
Manganese	Mn^{2+}	+2	Light pink
	Mn^{4+}	+4	Black/dark brown
	Mn^{6+}	+6	Green
	Mn^{7+}	+7	Purple
Iron	Fe^{2+}	+2	Green
	Fe^{3+}	+3	Dirty brown
Cobalt	Co^{2+}	+2	Pink
	Co^{3+}	+3	Blue
Nickel	Ni^{2+}	+2	Green
Copper	Cu^{+}	+1	Colourless
	Cu^{2+}	+2	Blue

3. Transition metals as catalysts

- Transition metals are effective catalysts because they can exist in many oxidation states and thus the partially filled d orbitals enable donation and acceptance of electrons very easily.

Examples

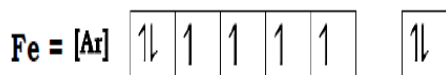
Transition metal	Use as catalyst
Iron (Fe)	Haber process - manufacture of ammonia
Nickel (Ni)	Hydrogenation of vegetable oils (to make margarines and soft-spreads)
Copper (Cu)	Oxidation of methanol
Transition metal compound	Use as catalyst
Manganese(III) oxide (Mn_2O_3)	Thermal decomposition of hydrogen peroxide and potassium chlorate
Vanadium(V) oxide (V_2O_5)	Contact Process (making of sulphuric acid)
Titanium(III) chloride (TiCl_3)	Polymerisation of ethane to polyethene

4. Paramagnetism

- Transition metals are **paramagnetic** as they are **attracted to the externally applied magnetic field**.
- The attraction is due to presence of one or more unpaired electrons which are attracted by the magnetic field.

Example

A very good example of a paramagnetic transition metal is iron (Fe). The orbital diagram for iron (Fe) is shown below.



Other examples of paramagnetic substances include: Cu^{2+} , Fe^{3+} and Cr^3

- Diamagnetic substances are weakly repelled by a magnetic field. (H_2O , NaCl , C_6H_6)
- Diamagnetism is shown by those substances in which all the electrons are paired and there are no unpaired electrons.

Exercise

1. State the colour of the following compounds.

- FeCl_3 - _____
- $\text{K}_2\text{Cr}_2\text{O}_7$ - _____
- MnO_4^{2-} - _____
- ZnSO_4 - _____ (4 marks)

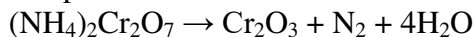
2. Consider the following metals: Fe, V, Zn

- Which metal does not form coloured compounds at room temperature? (1 mark)

b. Which metal has an oxide that is used as a catalyst in the synthesis of sulphuric acid?

(1 mark)

3. Consider the reaction below which shows the decomposition of ammonium dichromate.



- Calculate the oxidation number of Cr in $\text{Cr}_2\text{O}_7^{2-}$ and Cr_2O_3 respectively.

(2 marks)

- What may be the colours of $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ and Cr_2O_3 , respectively?

(2 marks)

4. Explain which of the following elements will form coloured compounds; magnesium or manganese. (1 mark)

5. Explain the term 'dative bonding' with a relevant example. (2 marks)

6. Explain why transition metals can form coloured compounds. Give examples to support your answer. (2 marks)

15. Explain why transition metals and their compounds are effective catalysts. Give an example of a transition metal that is used as a catalyst and state where it is used. (2 marks)

16. Differentiate between paramagnetism and diamagnetism. Give an example to support your answer. (2 marks)