TDC Part III
Paper VI
Inorganic Chemistry

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TOPIC:-UNIT II, MAGNETIC PROPERTIES, TYPES OF MAGNETIC BEHAVIOUR

UNIT -3 MAGNETIC PROPERTIES IN TRANSITION METAL COMPLEXES

OBJECTIVES

By going through this unit, you will be to understand magnetic properties of transition etal complexes and the magnetic susceptibility of a paramagnetic sample by measuring the force exerted on the sample by a magnetic field gradient.

INTRODUCTION

By studying the magnetic properties of a substance, we can get an insight into the distribution of electrons in the constituent atoms or ions. We know that the magnetic properties like magnetic moment and magnetic susceptibility arise due to the presence of unpaired electrons. The distinction between high spin and low spin complexes can be made on the basis of their magnetic properties. We observe that most of the transition metals and their salts and complexes have unpaired electrons spins about its axis and therefore, shows magnetic properties. It acts as a tiny magnet. The molecules with paired electrons are diamagnetic. This is because the paired electrons have their spins in opposite direction and their magnetic moments cancel each other. The picture is different in the case of molecules having unpaired electrons. The magnetic moments produced by individual electrons in this case are not cancelled, rather they reinforce each other.

TYPES OF MAGNETIC BEHAVIOUR

The salient features of various types of magnetic behaviours are as given below:

Paramagnetic substances

The substances which, when placed in magnetic field, allow the magnetic lines of force to pass through them rather than through vacuum, are called paramagnetic substances and the property due to which they show this behaviour is called paramagnetism.

Paramagnetism is subdivided in to (i) normal paramagnetism (ii) temperature independent and (iii) Pauli or free electron paramagnetism.

Origin of paramagnetism:

Paramagnetism of a substance consisting of atoms, ions or molecules is caused by the presence of unpaired electrons in the substance. The greater the number of unpaired electrons, the greater will be paramagnetism shown by the substance. Paramagnetic molecules are free to orient themselves ideally in the gas phase, but in practice, also in solution and even in the solid state, if magnetically dilute (Figure 3.1).

Diamagnetic substances

Substances which do not possess unpaired electrons (their electrons are paired), do not show any magnetic moment. Such substances are repelled by external magnetic field. This is because, the magnetic fields produced by paired electrons are neutralized and no net magnetic field is produced by them .

Origin of dimagnetism:

If two electrons with opposite spins are paired in the same orbital, the magnetic field produced by one electron is cancelled by that caused by the other electron, because each of the two electrons has equal and opposite magnetic moment. Thus, the substances having ony paired electrons give zero resultant magnetic moment and consequently are diamagnetic (Figure 3.1).

Dimagnetic property is temperature independent and is shown by all types of substances. Since diamagnetism is much weaker than paramagnetism (1 to 100 times weaker) and both act opposite to each other, it is difficult for the substances having unpaired electrons to show dimagnetism, i.e. the substances having unpaired electrons shows a net paramagnetism.

Ferromagnetism

In a normal paramagnetic material, the atoms containing the unpaired electrons are magnetically dilute, and so the unpaired electrons in one atom are not aligned with those in other atoms. However, in ferromagnetic materials, such as metallic iron, or iron oxides such as magnetite (Fe_3O_4), where the paramagnetic iron atoms are very close together, they can create an internal magnetic field strong enough that all the centers remain aligned (Figure 3.1).

Antiferromagnetism

The spins on the unpaired electrons become aligned in opposite directions so that the μ_{eff} approaches zero, in contrast to ferromagnetism, where μ_{eff} becomes very large. An example of anti- ferromagnetism is found in MnO (Figure 3.1).

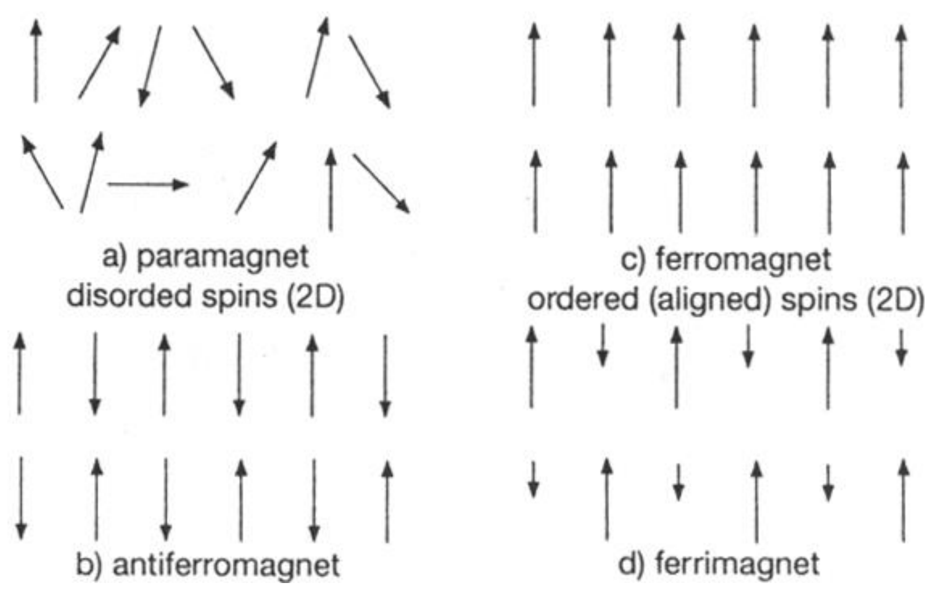

Figure. 3.1. *Types of magnetic behaviour in a substance*