Transition Metals: Review II

1. Write down configurations for the following metals:
    a. Ni
    b. Zr
    c. Cd^{2+}
    d. Ru^{3+}
    e. Mo^{4+}

2. Define each of the following
    a. Ligand
    b. Chelate
    c. Bidentate
    d. Complex ion

3. What must a ligand have in order to bond to a metal?

4. What do we mean when we say that a bond is a coordinate bond?

5. Name the following coordination compounds, and the complex ions:
    a) $(Co(NH_3)_6)Cl_2$
    b) $K_2(PtCl_4)$
    c) $Ru(NH_3)_5Cl^{2+}$
    d) $Fe(CN)_6^{4-}$

6. Why do transition metal ions often have several oxidation states, whil eother metals generally have one? Describe the maximum oxidation states observed along the series Sc→Zn, identifying the element with the highest oxidation state and give the value of this state. What is the most common oxidation state of the elements Co→Zn?

7. What is meant by a transition element? Summarize, with examples, the distinctive properties of transition elements and show how they are related to the electronic structure of these elements.

8. This questions concerns the d-block elements Sc→Zn

    a. Describe the general electronic configuration of these elements and the exceptional configurations of chromium and copper
    b. Describe the bonding in these elements. Use a bonding model to account for the general increase in melting points from Sc (1540°C) to Cr (1857°C), followed by a general decrease to Cu (1083) and Zn (420°C).
    c. Explain why the compounds of these elements are often coloured.
    d. Iron is an important d-block element. Identify one **physical property** of iron that is similar to that of calcium and one that is different. Account for similarities and the differences on the atomic level. Give two ways in which the properties of the **compounds** of iron differ from those of calcium.

ANSWERS: Transition Metals: Review II

1.
   a. [Ar] 3d8 4s2
   b. [Kr] 4d2 5s2
   c. [Kr] 4d10
   d. [Kr]4d 5
   e. [Kr]4d2

2.
   a. Ligand: neutral molecules or negative ions that contain a non-bonding pair of electrons
   b. Chelate: a ligand that can form more than one bond to a metal ion
   c. Bidentate: a ligand that bonds with two species
   d. Complex ion: metal ion at its centre with a number of other molecules or ions surrounding it

3. It must have a non-bonding pair of electrons that can be donated to the metal ion

4. It is a covalent bond that is formed when two atoms share a pair of electrons, however in this case both of the shared electrons come from one of the atoms.

6. Transition metals often have several oxidation states since the 4s and the 3d orbitals are similar in energy levels. Manganese has the highest number of oxidation states (5), the greatest oxidation state being +7 for manganese. The most common oxidation state is +2.

7. Transition elements are defined as elements that contain an incomplete 'd' level of electrons in one or more of their oxidation states. While it is common for a short period to experience large differences in physical properties, such as atomic radius, ionization energy, etc. going across a period, however the properties of TM remains fairly constant (atomic radii, IE). This is because transition metals generally differ in electrons in the inner d-shell, increasing going across the period. However, the chemistry of the electrons is mainly involved in the4 s orbitals, so going across the period, the increase of electrons in the inner d-shell helps to shield the s electrons, keeping the effective nuclear charge relatively constant.

8.

a. The general electronic configuration is [Ar] 3dn4s2 , exceptions being chromium ([Ar] 3d54s1) and Copper ([Ar] 3d104s1)

b. Transition metals have high melting points due to strong metallic bonds. The number of unpaired electrons in the valence shell indicates the strength of the metallic bonds. Therefore, the more unpaired electrons are present, the higher the melting point will be. Scandium to Chromium will have an increasing boiling point. However, as the unpaired d orbital electrons pair up, the melting point decreases (Copper to Zinc). Zinc has the lowest melting point because the d orbital electrons are filled.

c. Transition metals can form coloured complexes because the 4s orbital and 3d orbital are very similar in energy levels. The presence of ligands causes the d orbitals to go from being degenerate into non-degenerate. In the presence of visible light, the energy can cause an electron from the lower non-degenerate d-orbital to undergo transition to the higher non-degenerate d-orbital. The energy absorbed is complementary to the energy reflected, giving the compound its characteristic colour.

d. Iron and Calcium both can conduct electricity, however iron displays a higher melting/boiling point.

This is because one of the factors, which control melting point, is the number of electrons, which are involved in the metallic bond. In calcium, only the 4s electrons are involved. With iron, 3d electrons are involved as well, leading to a stronger metallic bond.
Iron compounds differ from calcium in that they form coloured complexes, and that they can act as catalysts.