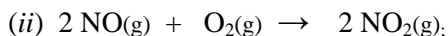
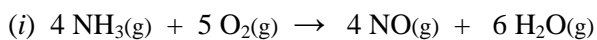


- The three most abundant metals in the Earth's crust are:  
(a) Silicon, calcium and magnesium; (b) Aluminum, iron and Calcium;  
(c) Iron, cobalt, and nickel; (d) Aluminum, Iron, and copper;
- The three most abundant element in dry atmosphere are:  
(a) Nitrogen, oxygen and argon; (b) Nitrogen, oxygen and carbon;  
(c) Nitrogen, oxygen and hydrogen; (d) Nitrogen, oxygen and water;
- Which is the most abundant minerals (ionic compound) in the Earth crust?  
(a) NaCl (b) Al<sub>2</sub>O<sub>3</sub> (c) CaCO<sub>3</sub> (d) CaSiO<sub>3</sub>
- Indicate the set of elements that shows the correct trend of increasing first ionization energy?  
(a) Li < B < Be (b) Na < Mg < Al (c) F < Cl < Br (d) None of them
- Identify the most polar covalent bond from the following list  
(a) B—Cl (b) B—F (c) C—F (d) B—Cl
- Although C and Si are in the same group, the compound SiO<sub>2</sub> does not exist as a discrete molecule like CO<sub>2</sub>. This is because:  
(a) The Si—O bond is unstable.  
(b) The Lewis structure of SiO<sub>2</sub> has an even number of electrons.  
(c) The 3p orbital of Si atom has little overlap with the 2p of O atom to form a pi-bond.  
(d) Si is a semi-metal.
- Which oxide of a Group 2A element has amphoteric properties?  
(a) BeO (b) MgO (c) CaO (d) None of them
- In the following list of oxides, identify the set that contains an acidic oxide, a basic oxide, and an amphoteric oxide?  
(a) Li<sub>2</sub>O, Na<sub>2</sub>O, K<sub>2</sub>O; (b) Na<sub>2</sub>O, MgO, Al<sub>2</sub>O<sub>3</sub>;  
(c) B<sub>2</sub>O<sub>3</sub>, Al<sub>2</sub>O<sub>3</sub>, In<sub>2</sub>O<sub>3</sub>; (d) CO<sub>2</sub>, NO<sub>2</sub>, SO<sub>2</sub>;
- The major industrial source of hydrogen gas is the reaction of methane and water at high temperatures (800 – 1000°C) and high pressures (10 – 15 atm) with nickel as a catalyst.  
$$\text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \xrightarrow{\text{Ni}} \text{CO}(\text{g}) + 3\text{H}_2(\text{g})$$
  
If 153.5 g of CH<sub>4</sub> and 153.5 g of H<sub>2</sub>O are reacted at 945°C and 12.0 atm, how much hydrogen should be available for industrial use?  
(a) 165 L (b) 239 L (c) 213 L (d) 572 L
- What product is formed when potassium is reacted with oxygen gas?  
(a) KO (b) K<sub>2</sub>O (c) K<sub>2</sub>O<sub>2</sub> (d) KO<sub>2</sub>
- This compound is used as dehumidifier in the air-conditioning unit.  
(a) LiCl (b) Li<sub>2</sub>CO<sub>3</sub> (c) Na<sub>2</sub>CO<sub>3</sub> (d) KCl

12. This compound is used to treat patients with manic depression.  
(a)  $\text{Li}_2\text{O}$                       (b)  $\text{Li}_2\text{CO}_3$                       (c)  $\text{MgSO}_4$                       (d)  $\text{CaSO}_4$
13. What chemical(s) is/are used in dry powder ABC type fire-extinguishers?  
(a)  $\text{Al}_2\text{O}_3$                       (b)  $\text{Al}_2\text{O}_3$  and  $\text{Na}_2\text{CO}_3$                       (c)  $\text{Na}_2\text{CO}_3$  and  $\text{NaHCO}_3$                       (d)  $\text{NaHCO}_3$
14. This compound of aluminum is used in the municipal water treatment plant.  
(a)  $\text{Al}_2\text{O}_3$                       (b)  $\text{Al}_2(\text{CO}_3)_3$                       (c)  $\text{Al}_2(\text{SO}_4)_3$                       (d)  $\text{Al}(\text{NO}_3)_3$
15. The three important ingredients for the manufacture of heat resistant (pyrex) glass are:  
(a)  $\text{SiO}_2$ ,  $\text{Na}_2\text{CO}_3$  and  $\text{B}_2\text{O}_3$ ;                      (b)  $\text{SiO}_2$ ,  $\text{Na}_2\text{CO}_3$  and  $\text{Al}_2\text{O}_3$ ;  
(c)  $\text{SiO}_2$ ,  $\text{NaHCO}_3$  and  $\text{MgO}$ ;                      (d)  $\text{SiO}_2$ ,  $\text{Na}_2\text{CO}_3$  and  $\text{MgO}$ ;
16. The molecular geometry of  $\text{PCl}_5$  has a \_\_\_\_\_ shape; the orbital hybridization on P is \_\_\_\_\_.  
(a) Square pyramidal;  $d^2sp^3$                       (b) Trigonal bipyramid;  $dsp^3$   
(c) See-saw;  $dsp^3$                       (d) Trigonal bipyramid,  $d^2sp^3$
17. Predict the molecular structure of  $\text{SF}_4$  and the orbital hybridization on the sulfur atom.  
(a) Trigonal bipyramidal;  $dsp^3$  hybridization;                      (b) Tetrahedral;  $sp^3$  hybridization;  
(c) Square planar;  $d^2sp^3$  hybridization;                      (d) See-saw shape;  $dsp^3$  hybridization;
18. Predict the molecular shape for  $\text{BrF}_5$  molecule and the orbital hybridization on Br.  
(a) Trigonal bipyramidal;  $d^2sp^3$  hybridization;                      (b) Square pyramidal;  $d^2sp^3$  hybridization  
(c) Trigonal bipyramid;  $dsp^3$  hybridization;                      (d) Pentagonal;  $d^2sp^3$  hybridization
19. All of the following contribute to nitrogen-fixation except:  
(a) Lightning                      (b) A certain bacterial family in soil;  
(c) The Haber process                      (d) The Ostwald process
20. Nitroglycerin,  $\text{C}_3\text{H}_5\text{N}_3\text{O}_9$ , the main component of dynamite, decomposes very rapidly and exothermically according to the equation:  
$$4\text{C}_3\text{H}_5\text{N}_3\text{O}_9(l) \rightarrow 6\text{N}_2(g) + 12\text{CO}_2(g) + 10\text{H}_2\text{O}(g) + \text{O}_2(g) + \text{energy}$$
  
What is the total volume of gaseous products that would be formed from 529 g of nitroglycerin? Assume that the heat of reaction caused the temperature and pressure of the mixture to increase to  $233^\circ\text{C}$  and 10.0 atm, respectively.  
(a) 32.3 L                      (b) 70.1 L                      (c) 14.5 L                      (d) 52.2 L
21. Which metal ion has  $[\text{Ar}] 3d^5$  electron configuration?  
(a)  $\text{Cr}^{2+}$                       (b)  $\text{Mn}^{2+}$                       (c)  $\text{Fe}^{2+}$                       (d) None of them
22. Which of the following metal ion has  $[\text{Ar}] 3d^7$  electron configuration?  
(a)  $\text{Mn}^{2+}$                       (b)  $\text{Fe}^{2+}$                       (c)  $\text{Co}^{2+}$                       (d)  $\text{Ni}^{2+}$

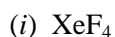
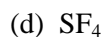
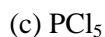
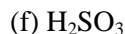
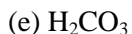
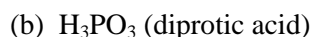
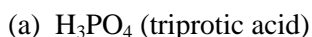
23. What is the maximum oxidation state expected for manganese?  
(a) +2 (b) +3 (c) +5 (d) +7
24. What is the correct electron configuration of the Nickel(II) ion?  
(a)  $[\text{Ar}] 4s^2 3d^6$  (b)  $[\text{Ar}] 4s^2 3d^8$  (c)  $[\text{Ar}] 3d^8$  (d)  $[\text{Ar}] 4s^1 3d^7$
25. What is the electron configuration of the Cobalt(III) ion?  
(a)  $[\text{Ar}] 4s^2 3d^4$  (b)  $[\text{Ar}] 4s^1 3d^5$  (c)  $[\text{Ar}] 4s^2 4p^4$  (d)  $[\text{Ar}] 3d^6$
26. Which of the metal ions in the following complex ions has a  $3d^5$  electron configuration?  
(a)  $[\text{Cr}(\text{NH}_3)_6]^{2+}$  (b)  $[\text{CoCl}_4]^{2-}$  (c)  $[\text{Fe}(\text{CN})_6]^{4-}$  (d)  $[\text{Fe}(\text{CN})_6]^{3-}$
27. What is the oxidation number of Pt in the coordination compound  $[\text{Pt}(\text{NH}_3)_2\text{Cl}_4]$ ?  
(a) +2 (b) +3 (c) +4 (d) +6
28. What is the coordination number of cobalt in the coordination compound  $[\text{Co}(\text{en})_2\text{Cl}_2]\text{Cl}$ ?  
(a) 4 (b) 5 (c) 6 (d) 8
29. Which of the following coordination compounds will form a precipitate when treated with an aqueous solution of  $\text{AgNO}_3$ ?  
(a)  $[\text{Cr}(\text{NH}_3)_3\text{Cl}_3]$  (b)  $[\text{Cr}(\text{NH}_3)_6]\text{Cl}_3$  (c)  $\text{Na}_3[\text{CrCl}_6]$  (d) All of them
30. When a 50.0-mL solution of 0.100 M  $[\text{Co}(\text{NH}_3)_5\text{Cl}]\text{Cl}_2$  is treated with an excess amount of  $\text{AgNO}_3$ , how many grams of  $\text{AgCl}$  will be produced?  
(a) 1.43 g (b) 2.15 g (c) 0.717 g (d) 717 g
31. Explain the following trends of atomic properties observed among elements in the periodic table.  
(a) Atomic size decreases from left to right and increases from top to bottom;  
(b) Ionization energy increases from left to right, but decreases from top to bottom;  
(c) Chemical reactivity of metals increases from top to bottom, whereas reactivity of nonmetals decreases from top to bottom.
32. (a) Seawater contains approximately 0.055 M  $\text{Mg}^{2+}$ . How many liters of seawater will produce 1.00 kg of magnesium? In the initial step of Dow process,  $\text{Mg}^{2+}$  is precipitated as  $\text{Mg}(\text{OH})_2(\text{s})$ , and the final step involves electrolysis of molten  $\text{MgCl}_2$  according to the following equations:  
(i)  $\text{Mg}^{2+}(\text{aq}) + \text{CaO}(\text{s}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{Mg}(\text{OH})_2(\text{s}) + \text{Ca}^{2+}(\text{aq})$   
(ii)  $\text{MgCl}_2(\text{l}) \rightarrow \text{Mg}(\text{s}) + \text{Cl}_2(\text{g})$   
(b) What is the minimum amount (in kg) of  $\text{CaO}$  required to precipitate all of  $\text{Mg}^{2+}$  in 1.00 m<sup>3</sup> (cubic meters) of seawater?  
(c) What is the hourly production of magnesium (in kg) during electrolysis that operates at a constant current of  $7.5 \times 10^4$  A and 4.5 V? (Assume 100% yield)  
(d) How many liters of  $\text{Cl}_2$  gas (measured at STP) are also produced per hour during electrolysis?  
(e) How much electrical energy is consumed to produce 1.00 kg of magnesium? Express the energy consumed in kJ and kWh, respectively.

33. Nitric acid is manufactured in the Oswald process, which involves the catalytic oxidation of ammonia according to the following equations:

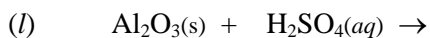
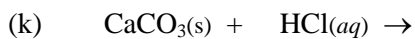
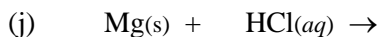
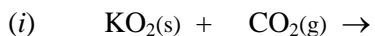
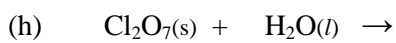
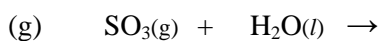
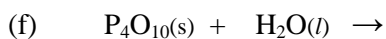
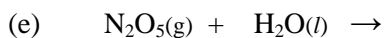
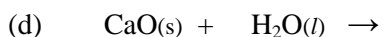
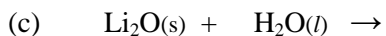
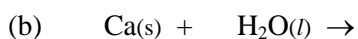
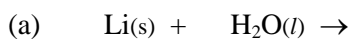


- (a) What is the mole fraction of  $\text{NH}_3$  that becomes nitric acid in one reaction cycle?  
(b) How many kilograms of  $\text{HNO}_3$  will be produced in one reaction cycle from  $1.00 \text{ m}^3$  ( $1.00 \times 10^3 \text{ L}$ ) of ammonia, measured at STP, if the reactions have an overall 92.0% yield?  
(c) If concentrated nitric acid contains 70.0% (by mass) of  $\text{HNO}_3$  and the solution has a density of 1.48 g/mL, how many liters of concentrated nitric acid solution will be produced from this process at the above reaction yield?
34. (a) Write all chemical reactions involved in the production of sulfuric acid starting from sulfur.  
(b) How many gallons of concentrated sulfuric acid (98.0% by mass; density = 1.84 g/mL) can be produced from 1.00 metric tonne ( $1.00 \times 10^3 \text{ kg}$ ) of sulfur? Assume that the reactions have an overall yield of 92.0%.

35. (a) Draw Lewis structures for the following molecules; (b) predict their molecular shapes, and indicate whether the molecules are polar or nonpolar.



36. Complete and balance the following equations.



37. Draw orbital “box” diagrams for each of the following atoms and ions. Indicate whether each atom and ion is diamagnetic or paramagnetic, and indicate which atom/ion is the most paramagnetic.

(a) Cr:

(b)  $\text{Cr}^{3+}$ :

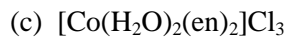
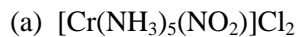
(c) Fe:

(d)  $\text{Fe}^{2+}$ :

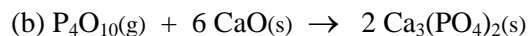
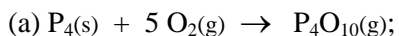
(e) Cu

(f)  $\text{Cu}^+$ :

38. Name the following coordination compounds. Determine the oxidation state and the coordination number of the transition metal in each compound.



39. Write Werner's formula of each of the following coordination compounds.
- Tetraamminediaquanickel(II) sulfate
  - Sodium tetrahydroxochromate(III)
  - Tetraaquaethylenediaminecopper(II) nitrate
40. A coordination compound is composed of 20.65% cobalt, 37.25% chlorine, and 42.10% ethylenediamine (en = H<sub>2</sub>NC<sub>2</sub>H<sub>4</sub>NH<sub>2</sub>), by mass. When 5.00 g of this compound is dissolved in 75.0 mL of deionized water, and the solution is reacted with excess AgNO<sub>3</sub>, it yields 2.47 g of AgCl precipitate. (a) Determine the empirical formula for the compound in the form of Co(en)<sub>x</sub>Cl<sub>y</sub> (where x and y are simple integers), and calculate its molar mass, assuming that the compound contains only one Co as the central metal ion. (b) In one mole of the compound, how many moles of chloride (Cl<sup>-</sup>) are counter ions, and how many chlorides are ligands? (c) Write the Werner's formula and give the systematic name according to Werner's method. (d) Draw all possible molecular structures of this compound and identify the geometric and optical isomers, if exist.
41. Compounds of chromium(III) are generally colored and paramagnetic, but those of scandium(III) are colorless and diamagnetic. Explain these observations. Would you expect the compound of titanium(III) to be colored or colorless; diamagnetic or paramagnetic? Explain.
42. The complex ion tetrahydroxonickelate(II), [Ni(OH)<sub>4</sub>]<sup>2-</sup>, is paramagnetic, whereas the complex ion tetracyanonickelate(II), [Ni(CN)<sub>4</sub>]<sup>2-</sup>, is diamagnetic. Deduce the molecular shapes of these complex ions and draw the crystal field energy diagram for the 3d orbitals of Ni<sup>2+</sup> in each complex ion.
43. Fe<sup>2+</sup> and Co<sup>3+</sup> are isoelectronic, each having the electron configuration [Ar] 3d<sup>6</sup>. The complex ion [Fe(H<sub>2</sub>O)<sub>6</sub>]<sup>2+</sup> is paramagnetic, whereas [Co(NH<sub>3</sub>)<sub>6</sub>]<sup>3+</sup> is diamagnetic. Explain using the crystal field model.
44. A solution containing the complex ion [Co(NH<sub>3</sub>)<sub>6</sub>]<sup>3+</sup> exhibit an absorption spectrum with λ<sub>max</sub> = 475 nm. (a) What is the color of the solution? (b) Calculate the octahedral crystal field (splitting) energy, Δ (in kJ/mol), in [Co(NH<sub>3</sub>)<sub>6</sub>]<sup>3+</sup>. (c) Would you expect a solution containing the complex ion [Co(H<sub>2</sub>O)<sub>6</sub>]<sup>3+</sup> to exhibit an absorption spectrum with λ<sub>max</sub> at the longer or shorter wavelength? Explain. (h = 6.626 x 10<sup>-34</sup> J.s.; c = 2.998 x 10<sup>8</sup> m/s; N<sub>o</sub> = 6.022 x 10<sup>23</sup>/mol, and 1 nm = 10<sup>-9</sup> m)
45. If pig iron contains 90% iron, 5% carbon, 0.3% phosphorus, and 4.7% other impurities, how many kilograms of calcium phosphate, Ca<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub>, are formed per metric ton of pure iron produced during the final refining process of iron in the basic oxygen furnace? The formation of calcium phosphate in basic oxygen furnace involves the following reactions:

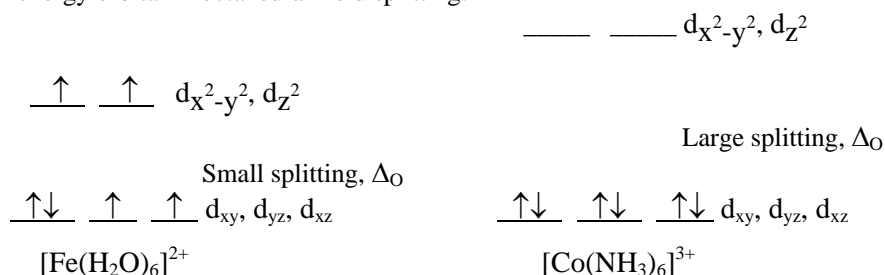


**Answers**

- 1.(b) 2. (a) 3. (c) 4. (a) 5. (b) 6. (c) 7. (a) 8. (c) 9. (c)  
10. (d) 11. (a) 12. (b) 13. (d) 14. (c) 15. (a) 16. (b) 17. (d) 18. (b)  
19. (d) 20. (b) 21. (b) 22. (c) 23. (d) 24. (c) 25. (d) 26. (d) 27. (c)  
28. (c) 29. (b) 30. (a)
31. (a) *Atomic size decreases left to right due to increasing effective nuclear attraction on the valence electron shell; it increases down the group because of increasing size of valence shells as the principal quantum number increases;*  
(b) *Ionization energy increases left to right across period because of increasing effective nuclear charge and decreasing atomic size – as nuclear attraction increase and decrease in atomic size, it requires more energy to remove a valence electron. As we go down the group, size increases and effective nuclear charge decreases, and less energy is required to remove a valence electron.*  
(c) *Metal reactivity increases from top to bottom because ionization energy decreases from top to bottom – metal atom with larger atomic size forms cation more readily ; nonmetal reactivity decreases down the group because electron affinity decreases from top to bottom – the tendency to become anion decreases going down the group.*
32. (a) 748 L of seawater; (b) 3.08 kg CaO; (c) 34 kg of Mg; (d)  $3.1 \times 10^4$  L of Cl<sub>2</sub>;  
(e)  $3.6 \times 10^4$  kJ; 9.9 kWh
33. (a) 2/3 (b)  $2.16 \times 10^3$  kg; (c)  $2.08 \times 10^3$  L of concentrated HNO<sub>3</sub>;
34. (a) (i)  $S_8(s) + 8 O_2(g) \rightarrow 8 SO_2(g)$ ;  
(ii)  $2 SO_2(g) + O_2(g) \rightarrow 2 SO_3(g)$ ;  
(iii)  $SO_3(g) + H_2SO_4(l) \rightarrow H_2S_2O_7(l)$ ;  
(iv)  $H_2S_2O_7(l) + H_2O(l) \rightarrow 2 H_2SO_4(l)$ ;  
(b) 412 gallons of concentrated H<sub>2</sub>SO<sub>4</sub>;
36. (a)  $2Li(s) + 2H_2O(l) \rightarrow 2LiOH(aq) + H_2(g)$   
(b)  $Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)$   
(c)  $Li_2O(s) + H_2O(l) \rightarrow 2 LiOH(aq)$ ;  
(d)  $CaO(s) + H_2O(l) \rightarrow Ca(OH)_2(aq)$ ;  
(e)  $N_2O_5(g) + H_2O(l) \rightarrow 2 HNO_3(aq)$ ;  
(f)  $P_4O_{10}(s) + 6 H_2O(l) \rightarrow 4 H_3PO_4(aq)$ ;  
(g)  $SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$ ;  
(h)  $Cl_2O_7(s) + H_2O(l) \rightarrow 2 HClO_4(aq)$ ;  
(i)  $4KO_2(s) + 2CO_2(g) \rightarrow 2K_2CO_3(s) + 3 O_2(g)$   
(j)  $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$   
(k)  $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$   
(l)  $Al_2O_3(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3H_2O(l)$

37. (a) Cr: [Ar]  $\frac{\uparrow}{4s^1}$   $\frac{\uparrow}{3d^5}$   $\frac{\uparrow}{3d^5}$   $\frac{\uparrow}{3d^5}$   $\frac{\uparrow}{3d^5}$   $\frac{\uparrow}{3d^5}$  paramagnetic  
 (b) Cr<sup>3+</sup>: [Ar]  $\frac{\uparrow}{4s}$   $\frac{\uparrow}{3d^3}$   $\frac{\uparrow}{3d^3}$   $\frac{\uparrow}{3d^3}$  paramagnetic  
 (c) Fe: [Ar]  $\frac{\uparrow\downarrow}{4s^2}$   $\frac{\uparrow\downarrow}{3d^6}$   $\frac{\uparrow}{3d^6}$   $\frac{\uparrow}{3d^6}$   $\frac{\uparrow}{3d^6}$   $\frac{\uparrow}{3d^6}$  paramagnetic  
 (d) Fe<sup>2+</sup>: [Ar]  $\frac{\uparrow\downarrow}{4s}$   $\frac{\uparrow}{3d^6}$   $\frac{\uparrow}{3d^6}$   $\frac{\uparrow}{3d^6}$   $\frac{\uparrow}{3d^6}$   $\frac{\uparrow}{3d^6}$  paramagnetic  
 (e) Cu: [Ar]  $\frac{\uparrow}{4s^1}$   $\frac{\uparrow\downarrow}{3d^{10}}$   $\frac{\uparrow\downarrow}{3d^{10}}$   $\frac{\uparrow\downarrow}{3d^{10}}$   $\frac{\uparrow\downarrow}{3d^{10}}$   $\frac{\uparrow\downarrow}{3d^{10}}$  paramagnetic  
 (f) Cu<sup>+</sup>: [Ar]  $\frac{\uparrow\downarrow}{4s}$   $\frac{\uparrow\downarrow}{3d^{10}}$   $\frac{\uparrow\downarrow}{3d^{10}}$   $\frac{\uparrow\downarrow}{3d^{10}}$   $\frac{\uparrow\downarrow}{3d^{10}}$   $\frac{\uparrow\downarrow}{3d^{10}}$  diamagnetic

38. (a) Pentaamminenitrochromium(III) chloride; (b) Potassium tetracyanoaurate(III)  
 (c) Diaquabis(ethylenediamine)cobalt(III) chloride.
39. (a) [Ni(H<sub>2</sub>O)<sub>2</sub>(NH<sub>3</sub>)<sub>4</sub>]SO<sub>4</sub>; (b) Na[Cr(OH)<sub>4</sub>]; (c) [Cu(H<sub>2</sub>O)<sub>4</sub>(en)](NO<sub>3</sub>)<sub>2</sub>;
40. (a) Empirical formula = Co(en)<sub>2</sub>Cl<sub>3</sub>; molar mass = 285.48 g/mol;  
 (b) Mole of compound dissolved = 0.0175 mol; mole of AgCl produced = 0.172 mol; number of Cl<sup>-</sup> as counter ion = 1; number of Cl<sup>-</sup> as ligand = 2; (c) Werner's formula = [Co(en)<sub>2</sub>Cl<sub>2</sub>]Cl = Dichlorobis(ethylenediamine)cobalt(III) chloride; (d) *cis*- dichlorobis(ethylenediamine)cobalt(III) chloride and *trans*- dichlorobis(ethylenediamine)cobalt(III) chloride; the *cis*- form has non-superimposable mirror image isomer (or enantiomer), and is optically active.
41. Cr<sup>3+</sup> has electron configuration: [Ar] 3d<sup>3</sup>, whereas Sc<sup>3+</sup> has [Ne] 3s<sup>2</sup> 3p<sup>6</sup>. Electronic transitions between the split 3d orbitals results in the absorption of a portion of visible light, which results in a colored chromium(III) compounds. Since scandium(III) does not have electron in the 3d subshell, there is no electronic transition between the split 3d-orbitals and there is no absorption of light in the visible region, which results in a colorless solution for any scandium compound.
42. Nickel(II) has the electron configuration: [Ar] 3d<sup>8</sup>, which would yield a paramagnetic ions in both octahedral and tetrahedral complexes. The only way a complex ion containing nickel(II) is diamagnetic is by having a square planar structure. Since [Ni(OH)<sub>4</sub>]<sup>-</sup> is paramagnetic, it must have a tetrahedral structure, and [Ni(CN)<sub>4</sub>]<sup>-</sup> must be a square planar complex.
43. Fe<sup>2+</sup> ion has lower charge density compared to Co<sup>3+</sup> and H<sub>2</sub>O is a weaker ligand than NH<sub>3</sub>. The combination of low charge density on the metal ion and weaker ligands results in a smaller splitting of 3d orbitals energy level in the octahedral field. This resulted in a high spin complex ion (with 4 unpaired electrons) for complex ions containing Fe<sup>2+</sup>. While the combination of high charge density of Co<sup>3+</sup> and stronger ligands results in a greater splitting of 3d orbital energy level, and this resulted in a low spin or a diamagnetic complex with all six 3d electrons occupy the three lower energy orbital in octahedral field splitting.



44. (a) 475 nm is in the blue region of the visible spectrum; if the color absorbed in blue, the complex ion would exhibit an orange color (the complimentary color to blue). (b) Octahedral field splitting energy,  $\Delta_O = 252$  kJ/mol; (c) Since H<sub>2</sub>O is a weaker ligand, it would result in a smaller octahedral splitting of 3d orbitals energy, and the absorption  $\lambda_{\text{max}}$  would shift to the longer wavelength region of the visible spectrum.
45. 17 kg of Ca<sub>3</sub>(PO<sub>4</sub>)<sub>2</sub> are produced per metric ton of iron.