**Useful data:** **Speed of light : 2.9979 X $10^{8}$ m/s**
**Planck's constant : 6.626 X $10^{-34}$ Js**
**$E_n$ = -2.179 X $10^{-18}$ J/$n^2$**

1. (15) (a) (3) What is the maximum number of electrons in the 2p subshell of an atom?

**6**

(b) (3) Give the complete set of quantum numbers for each of these electrons

| n | l | $m_l$ | $m_s$ |
|---|---|---|---|
| 2 | 1 | -1 | -1/2 |
| 2 | 1 | -1 | +1/2 |
| 2 | 1 | 0 | -1/2 |
| 2 | 1 | 0 | +1/2 |
| 2 | 1 | +1 | -1/2 |
| 2 | 1 | +1 | +1/2 |

(c) (3) Choose the largest atom among the following: Ge, As, Sn, Sb

**Sn**

(d) (3) Choose the most electronegative atom among the following: S, Se, Cl, Br

**Cl**

(e) (3) Put the atoms Cr, Zn, W in order of increasing ionization energy

**W < Cr < Zn**

2. (a) (7) Calculate the frequency and wavelength of the spectral line of hydrogen corresponding to a transition of an electron from n=6 to n=3.

**$\Delta E = -2.179\ 10^{-18}\ (1/6^2 - 1/3^2) = 0.1816\ 10^{-18}$ J**

**$\Delta E = hv \Rightarrow v = 2.740\ 10^{14}\ s^{-1}$**

**$c = \lambda v \Rightarrow \lambda = 1.094\ 10^{-6}$ m or 1094 nm**

b) (3) In what region of the electromagnetic spectrum would this spectral line be?

**IR**

3. (15) What is the electron configuration of the following elements or ions (use noble gas core abbreviated notation):

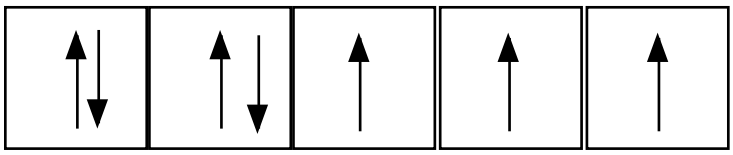
a) Si

**[Ne] $3s^2\ 3p^2$**

b) $Co^{2+}$

**[Ar] $3d^7$**

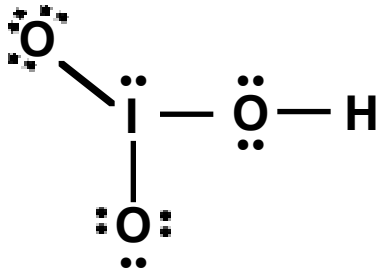
(c) Show the orbital diagram for $Co^{2+}$ and say whether it is diamagnetic or paramagnetic.



**3d**

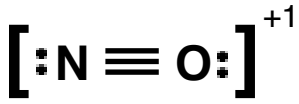
**Paramagnetic**

4. (10) Draw a Lewis structure that satisfies the octet rule for iodic acid ($HIO_3$) and indicate the formal charge on each atom.

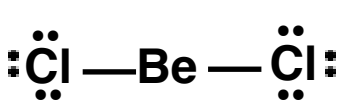


**Formal charges: +2 on I, -1 on terminal Os, zero on other atoms.**

5. (10) Draw a Lewis structure for the $NO^+$ ion.



6. (10) Below are two Lewis structures for $BeCl_2$. Which one is better and why? (give two reasons)



**The one on the left is better because:**
**a) the formal charges are zero**
**b) the one on the right has a +1 formal charge on a very electronegative atom**

7. (a) (12) Use data from the tables of ionization energies and electron affinities to calculate energy changes for the following reactions:

$Na\ (g) + Cl\ (g) \rightarrow Na^+\ (g) + Cl^-\ (g)$

$Na\ (g) + 2\ Cl\ (g) \rightarrow Na^{2+}\ (g) + 2\ Cl^-\ (g)$

(b) (3) How much larger would the lattice energy of $NaCl_2$ have to be compared to the lattice energy of NaCl for $NaCl_2$ to be more stable than NaCl ?

**a) The energy change for the first reaction is the first ionization energy of Na plus the electron affinity of Cl : 496-349 = +147 kJ**

**The energy change for the second reaction is the first ionization energy of Na plus the second ionization energy of Na, plus twice the electron affinity of Cl : 496+ 4562-2*349 = +4360 kJ**

**b) For $NaCl_2$ to be more stable than NaCl, its lattice energy of $NaCl_2$ would have to be 4360 – 147= 4213 kJ larger than that of NaCl (it's not, that's why $NaCl_2$ is not observed)**

8. (15) Use bond energy data to estimate the enthalpy change for the following reaction:

$CH_4 + 2\ O_2 \quad \text{----> } CO_2 + 2\ H_2O$

Is it exothermic or endothermic?

**$\Delta H$ = bond energy of reactants – bond energy of products**
**= $4\ D_{CH} + 2\ D_{O=O} - 2\ D_{C=O} - 4\ D_{HO}$**
**= 4*414 + 2*498 -2*799 -4*464 = -802 kJ (exothermic)**

**(this is approximate. The experimental value is -890 kJ)**