1. Electromagnetic radiation of λ = 242 nm (this is in the U.V. range) is just energetic enough to cause the photoelectric effect in sodium. Calculate the ionization energy of sodium in kJ/mol.

20%

$$E = \frac{hc}{\lambda} = \frac{(6.626\times10^{-34}\ J\cdot s)(3.00\times10^{8}\ m/s)}{242\times10^{-9}\ m}$$

$$= 8.21049587\times10^{-19}\ J$$

$$= 8.21\times10^{-19}\ J$$

This is the amount of energy required to ionize a single sodium atom.

To ionize 1 mol of sodium atoms:

$$E = (8.21049587\times10^{-19}\ J/atom)\times\frac{6.022\times10^{23}\ atoms}{1\ mol}\times\frac{1\ kJ}{1000\ J}$$

$$= 494.6500661\ kJ/mol$$

$$\boxed{E = 495\ kJ/mol}$$

∴ The ionization energy of sodium is 495 kJ/mol.

2. For ruthenium, $_{44}Ru$:
   a. Give the electron configuration
20% b. Identify the valence subshell(s). Give the orbital diagram and the quantum numbers for all electrons in the valence subshell(s).
   c. Identify the highest energy subshell. Give the orbital diagram and the quantum numbers for all electrons in the highest energy subshell, if different from b).
   d. Give the electron configuration for the ruthenium ion, Ru^{4+}.

a) Ru: $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^6$

or

Ru: $[Kr] 5s^2 4d^6$

b) valence subshell: $n=5$

$5s^2$ $\uparrow\downarrow$ $(5,0,0,\pm\frac{1}{2})$

c) highest E subshell: $4d^6$

$4d^6$ $\uparrow\downarrow$ $\uparrow$ $\uparrow$ $\uparrow$ $\uparrow$ $(4,2,-2,\pm\frac{1}{2})$ $(4,2,-1,\frac{1}{2})$ $(4,2,0,\frac{1}{2})$ $(4,2,1,\frac{1}{2})$ $(4,2,2,\frac{1}{2})$

d) Ru^{4+}: electrons removed from the valence 1st, then continuing in decreasing energy.

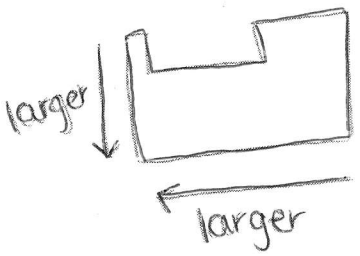
Ru^{4+}: $[Kr](5s^0)4d^4$ ← removed 2nd; ↖ removed 1st

3. For the following elements: Al, Ne, K, P, Cl, Mg, F

20% a. Rank in order of **increasing** size

b. Rank in order of **increasing** ionization energy

a) size:



Ne < F

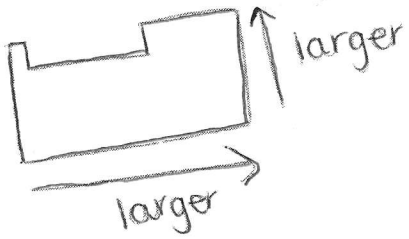
Mg < K

F < Cl

Cl < P < Al < Mg

∴ Ne < F < Cl < P < Al < Mg < K

b) ionization energy:



F < Ne

K < Mg

Cl < F

Al < P < Cl

Mg > Al → based on elec. config

(3s²) (3s²3p¹)

∴ K < Al < Mg < P < Cl < F < Ne

4. Give the IUPAC (systematic) name for the following:

20%

a. $MgBr_2$ b. V_2O_3 c. $NiPO_4$ d. H_2O

Give the chemical formula for the following:

e. Lead sulfate f. Zinc (II) sulfide g. Ammonium nitrate

a) $MgBr_2$

$Mg^{2+} + 2Br^-$

ionic

∴ magnesium bromide

b) V_2O_3

ionic

$2V^{3+} + 3O^{2-}$

↖ transition metal.

∴ Vanadium (III) oxide

c) $NiPO_4$

$Ni^{3+} + PO_4^{3-}$

∴ Nickel (III) phosphate

d) H_2O

covalent

$2H^+ + O^{2-}$

dihydrogen monoxide

e) Lead sulfate

$Pb^{4+} + SO_4^{2-}$

∴ $Pb(SO_4)_2$

f) zinc (II) sulfide

$Zn^{2+} + S^{2-}$

∴ ZnS

g) Ammonium nitrate

$NH_4^+ + NO_3^-$

∴ NH_4NO_3

20%

5. For phosphorus trichloride, PCl_3,
   a. Show the Lewis diagram
   b. Give the bond order for each bond
   c. Draw and name the VSEPR geometry

a) Val. e⁻:

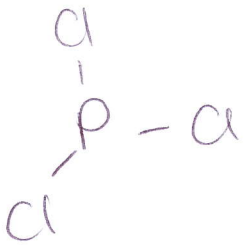
P → 5 e⁻

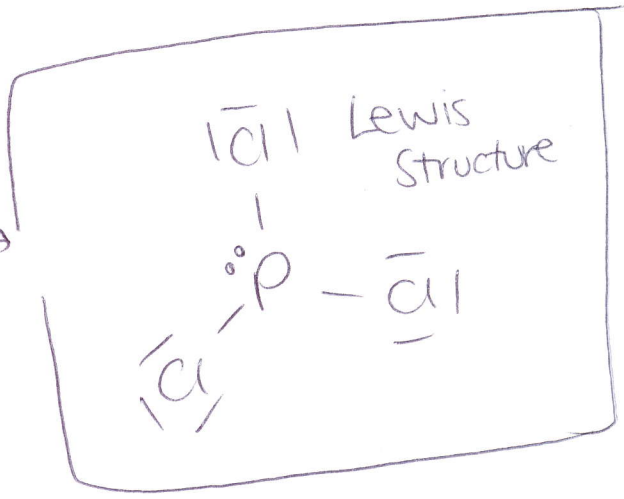
Cl → 3 × 7 e⁻

26 e⁻

− 6 e⁻

20 e⁻ left





F.C.

P: 5 − (2 + 3) = 0

Cl: 7 − (6 + 1) = 0

∴ There are no formal charges in this structure.

b) Bond order:

each P–Cl bond is a single bond.

∴ Bond order each = 1

c) Regions e⁻ density:

3 bonds

+ 1 Lone pair

4 regions total.

∴ Based on tetrahedral.