

MINISTRY OF HEALTH OF UKRAINE
BOGOMOLET'S NATIONAL MEDICAL UNIVERSITY

Department of Medical and General Chemistry

INORGANIC CHEMISTRY

Student notebook for pre-lab tasks

(Module 2 «Chemical Elements»)

Student _____

Group _____

Kyiv 2016

Approved by Methodical Commission of Physicochemical Disciplines of
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This Student Notebook for Pre-lab tasks includes questions in all basic topics in Inorganic Chemistry course and allows you to keep a written record of them. The notebook is for first year foreign students of Pharmaceutical Faculty.

Module 2. «Chemical elements»

Semantic Module 5. p - Elements of the III-VIII groups of the periodic table of elements

Topic 1. General characteristics of the p-elements. Hydrogen and its compounds.

1. What oxidation states (numbers) are characteristic for hydrogen and its compounds?
2. What types of chemical bonds form hydrogen in binary compounds with other elements?
Give examples of binary compounds of hydrogen with various types of chemical bonds.
3. Which of the metals can be used to produce H_2 from hydrochloric acid (HCl): Cu, Al, Fe, Mg, Au, Ag, Hg, Zn? Write reactions.
4. Assign the oxidation number of hydrogen in following compounds:
 H_2O , H_2O_2 , NaH, PH_3 , H_2 , CH_4 , C_2H_4 , H_2S , HCl
5. What substances – S, P, N, Cl, Cu, Zn, Al, Au, Pt, H_2O , SO_2 , P_2O_5 , $Cu(OH)_2$, FeO – react with H_2 ? Write reactions.

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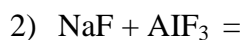
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Module 2. «Chemical elements»

Semantic Module 5. p - Elements of the III-VIII groups of the periodic table of elements

Topic 2. p-elements of the VIIA group. Halogens. Halogens compounds in negative oxidation states.

1. What is the electronic configuration of halogen atoms?
2. What oxidation numbers are characteristic for halogens in compounds?
3. Hydrogen halides: write formulas and characterize their reducing properties.
4. Which of the hydrogen halides (HF, HCl, HBr, HI) react with sulfuric acid? Write reactions.
5. Complete and balance equations for the following reactions:
 - 1) $\text{KMnO}_4 + \text{KBr} + \text{H}_2\text{SO}_4 =$



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Semantic Module 5. p - Elements of the III-VIII groups of the periodic table of elements

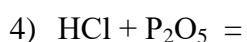
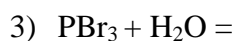
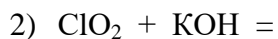
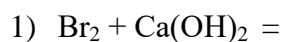
Topic 3. p-elements of the VIIA group. Halogens. Halogens compounds in positive oxidation states.

1. Write the reaction for preparation of chlorine water, bleaching powder.
2. Write the reactions of potassium chlorate, potassium bromate, potassium iodate decomposition.
3. Explain a change of stability, oxidizing and acidic properties in a following rows:

| Row | Stability | Oxidizing properties | Acidic properties |
|---|-----------|----------------------|-------------------|
| $\text{HClO} \rightarrow \text{HClO}_2 \rightarrow \text{HClO}_3 \rightarrow \text{HClO}_4$ | | | |
| $\text{HClO} \rightarrow \text{HBrO} \rightarrow \text{HIO}$ | | | |

4. Which of the oxyacids is most stable?

5. Complete and balance equations for the following reactions:



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Module 2. «Chemical elements»

Semantic Module 5. p - Elements of the III-VIII groups of the periodic table of elements

Topic 6. p-elements of the VA group. Nitrogen. Compounds of nitrogen in positive oxidation states.

1. Write formulas of all nitrogen oxides. Name them.

2. Which of nitrogen oxides react with $\text{Ca}(\text{OH})_2$ solution? Write reactions.

3. Write the reactions of the following salts decomposition:

a) $\text{NaNO}_3 =$

b) $\text{AgNO}_3 =$

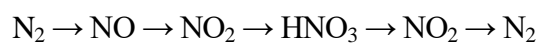
c) $\text{Al}(\text{NO}_3)_3 =$

d) $\text{Pb}(\text{NO}_3)_2 =$

4. What substances – P_2O_5 ; HCl ; C ; I_2 ; CaO ; Cu ; Al ; CO_2 – react with concentrated nitric acid?

Write reactions.

5. Propose the reactions necessary for the following transformations:



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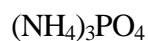
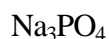
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Module 2. «Chemical elements»

Semantic Module 5. p - Elements of the III-VIII groups of the periodic table of elements

Topic 7. p-elements of the VA group. Phosphorus and its compounds.

1. What is the electronic configuration of the phosphorus atom and its ions?
2. Write formulas of phosphorus oxides. Name them.
3. Write hydrolysis reactions of the following salts in ionic and molecular forms and notice the pH of solution (acidic, basic or neutral):



4. Complete and balance equations for the following reactions:



5. Propose the reactions necessary for the following transformations:

calcium phosphate \rightarrow phosphorus \rightarrow phosphorus (V) oxide \rightarrow phosphoric acid \rightarrow sodium phosphate
 \rightarrow sodium hydrogen phosphate \rightarrow barium phosphate

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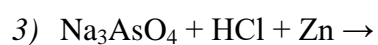
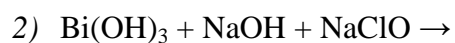
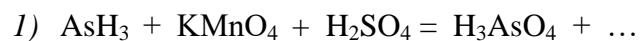
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Semantic Module 5. p - Elements of the III-VIII groups of the periodic table of elements

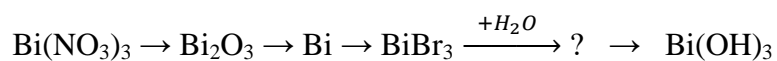
Topic 8. p-elements of the VA group. Arsen subgroup (Arsen, Antimony, Bismuth).

1. Write the electronic configuration of Arsen, Antimony and Bismuth atoms.
2. Give examples of compounds in which Arsen, Antimony and Bismuth have oxidation number -3 . Name them.
3. Write formulas of the Arsen, Antimony and Bismuth oxides.

4. Complete and balance equations for the following reactions:



5. Propose the reactions necessary for the following transformations:



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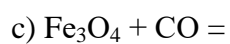
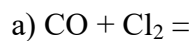
Topic 9. p-elements of the IVA group. Carbon and Silicium.

Questions for admission to the implementation of practical and laboratory works:

1. Write the electronic configuration of Carbon and Silicium atoms and its ions.

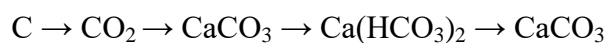
2. Describe types of hybridization for Carbon and Silicon atoms.

3. Complete and balance equations for the following reactions:



4. What substances – H_2O , CaO , BaCO_3 , NaOH , CO , C , P_2O_5 – react with CO_2 ? Write reactions.

10. Propose the reactions necessary for the following transformations:



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Module 2. «Chemical elements»

Semantic Module 5. p - Elements of the III-VIII groups of the periodic table of elements

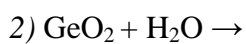
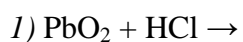
Topic 10. p-elements of the IVA group. Germanium subgroup (Germanium, Stannum, Lead).

1. In which acids can be dissolved Germanium, Stannum and Lead? Write reactions.

2. Write the reactions of Stannum and Lead with alkalis.

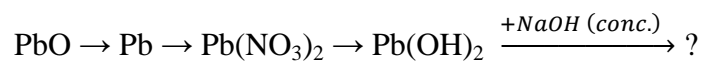
3. Describe amphoteric properties of SnO and PbO.

4. Complete and balance equations for the following reactions:





5. Propose the reactions necessary for the following transformations:



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Module 2. «Chemical elements»

Semantic Module 5. p - Elements of the III-VIII groups of the periodic table of elements

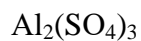
Topic 11. p-elements of the IIIA group. Boron and Aluminium

1. Describe the type of hybridization AO of Boron in molecule BCl_3 .

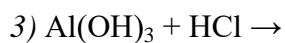
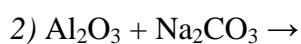
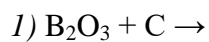
2. What coordination numbers are typical for coordination compounds of Aluminium? Give an examples.

3. Write reactions of Aluminium with O₂, N₂, C, S, F₂.

4. Write hydrolysis reactions for the following salts:



5. Complete and balance equations for the following reactions:



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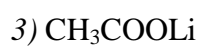
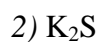
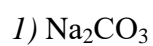
Module 2. «Chemical elements»

Semantic Module 6. s-Elements (typical metals)

Topic 12. s-elements of the I group. Alkali metals

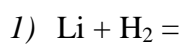
1. Describe electron configurations and energy diagrams of elements of the I group: lithium, sodium, potassium, caesium.

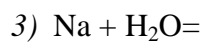
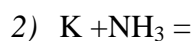
2. Write hydrolysis reactions in the molecular and ionic forms.



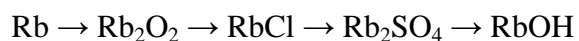
3. Which of the following formulas belong to alkalis: $\text{Be}(\text{OH})_2$, $\text{Mg}(\text{OH})_2$, $\text{Cu}(\text{OH})_2$, NaOH , $\text{Ba}(\text{OH})_2$? Underline them.

4. Complete and balance equations for the following reactions:





5. Propose the reactions necessary for the following transformations:



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Module 2. «Chemical elements»

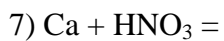
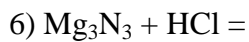
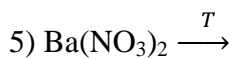
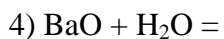
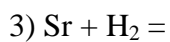
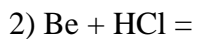
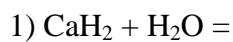
Semantic Module 6. s-Elements (typical metals)

Topic 13. Elements of the II group. Beryllium, magnesium and alkali-earth metals

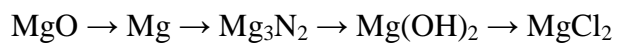
1. Write electron configurations for magnesium, calcium, barium and beryllium ions.

2. What volume of CO_2 is produced from the thermal decomposition of 10 g CaCO_3 ?

3. Complete and balance equations for the following reactions:

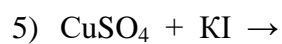


5. Make the reactions necessary for the following transformations:

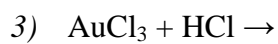
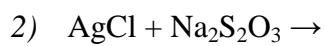
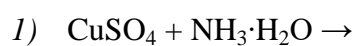


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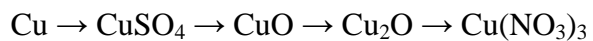
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4. Write the reactions of complex formation. Give the name of complex compound.



5. Make the reactions necessary for the following transformations:



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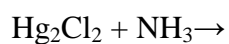
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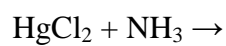
Module 2. «Chemical elements»

Semantic Module 7. d-Elements of the I - VIII groups of the periodic table of elements

Topic 15. d-elements of the IIB group. Zinc, Cadmium, Mercury.

1. Write reactions between zinc and concentrated sulfuric acid, zinc oxide and sodium hydroxide.
2. Describe chemical properties of zinc hydroxide.
3. Write reaction between cadmium sulfite and ammonia solution.
4. Write reaction between mercury and concentrated nitric acid.
5. Write the net ionic equations for the reaction:





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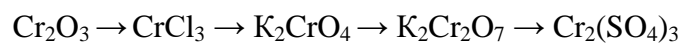
Module 2. «Chemical elements»

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Topic 16. d-elements of the VIA group. Chromium subgroup.

1. Write electron configurations for chromium, molybdenum and wolfram ions.

2. Make the reactions necessary for the following transformation:



3. What volume of chlorine is formed as result of reaction between one mole of potassium dichromate and hydrochloric acid?

4. Write reaction equation between chromium (III) sulfate and sodium carbonate.

5. Complete and balance equations for the following reactions:



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3. Write reaction equation which characterized oxidizing properties of potassium permanganate depend on acidity of solution.

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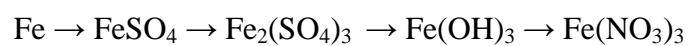
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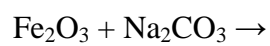
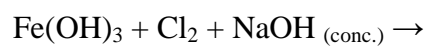
Topic 18. d-elements of the VIIIA group. Iron and its compounds. Cobalt and Nickel compounds. Platinum metals.

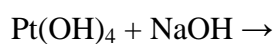
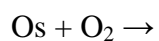
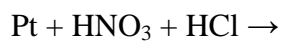
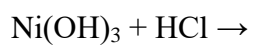
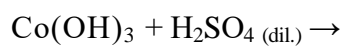
1. What substances – H_2S , HCl , Mg , Sn , BaCl_2 , NaCl , CuCl_2 , KMnO_4 (in the presence of H_2SO_4), NaOH – interact with iron (II) sulfate? Write chemical equations for the corresponding reactions.

2. Make the reactions necessary for the following transformation:



3. Complete and balance equations for the following reactions:





4. Write coordination compounds using the following data:

a) central ion – Co^{3+} , Ni^{2+} ;

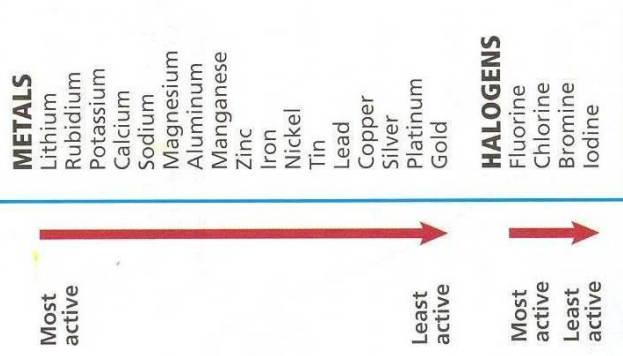
b) coordination number – 6;

c) ligands – NH_3 ;

d) outer sphere – ions Cl^- .

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Solubility of Ionic Compounds in Water

Key: S = soluble; I = insoluble; D = decomposes in water; U = compound does not exist

| Cation | Al ³⁺ | NH ₄ ⁺ | Ba ²⁺ | Cd ²⁺ | Ca ²⁺ | Cr ³⁺ | Co ²⁺ | Cu ²⁺ | Fe ³⁺ | Fe ²⁺ | H ⁺ | Pb ²⁺ | Mg ²⁺ | Hg ¹⁺ | Ni ²⁺ | K ¹⁺ | Ag ¹⁺ | Na ¹⁺ | Sr ²⁺ | Zn ²⁺ |
|---|------------------|------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|-----------------|------------------|------------------|------------------|------------------|
| Anion | | | | | | | | | | | | | | | | | | | | |
| C ₂ H ₃ O ₂ ⁻ | S | S | S | S | S | S | S | S | S | S | S | S | S | I | S | S | I | S | S | S |
| Br ⁻ | S | S | S | S | S | S | S | S | S | S | S | S | S | I | S | S | I | S | S | S |
| CO ₃ ²⁻ | U | S | I | I | I | U | I | I | U | I | S | I | I | I | I | S | I | S | I | I |
| ClO ₃ ⁻ | S | S | S | S | S | U | S | S | U | U | S | S | S | S | I | S | S | S | S | S |
| Cl ⁻ | S | S | S | S | S | S | S | S | S | S | S | S | S | I | S | S | I | S | S | S |
| CrO ₄ ²⁻ | U | S | I | I | S | U | I | S | I | I | S | I | I | I | U | S | I | S | I | I |
| OH ⁻ | I | I | S | I | I | I | I | I | I | I | H ₂ O | I | I | U | I | S | U | S | I | I |
| I ⁻ | S | S | S | S | S | S | S | S | S | S | S | I | S | I | S | S | I | S | S | S |
| NO ₃ ⁻ | S | S | S | S | S | S | S | S | S | S | S | S | S | D | S | S | S | S | S | S |
| O ²⁻ | I | U | S | I | I | I | I | I | I | I | H ₂ O | I | I | I | I | D | I | D | I | I |
| C ₂ O ₄ ²⁻ | I | I | I | I | I | S | I | I | S | I | S | I | I | I | I | S | I | S | I | I |
| PO ₄ ³⁻ | I | S | I | I | I | I | I | I | I | I | S | I | I | U | I | S | I | S | I | I |
| SiO ₃ ²⁻ | I | U | S | I | I | U | I | U | U | I | I | I | I | U | U | S | U | S | I | I |
| SO ₄ ²⁻ | S | S | I | S | I | S | S | S | S | S | S | I | S | I | S | S | I | S | I | S |
| S ²⁻ | D | S | D | I | I | I | I | I | I | I | S | I | D | I | I | S | I | S | I | I |
| SO ₃ ²⁻ | U | S | I | I | I | I | I | U | U | I | S | I | U | U | I | S | I | S | I | I |

PERIODIC TABLE OF THE ELEMENTS

| 1 IA | | 2 IIA | | 3-10 IIIB-VIIB | | | | | | | | | | 11 IB | | 12 IIB | | 13 IIIA | | 14 IVA | | 15 VA | | 16 VIA | | 17 VIIA | | 18 VIII A | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-------------------------------------|------------------------------------|---------------------------------------|---|--|---|--|---|--|---------------------------|--|---|---|--|--|---|---|---|--|--|---|--|--|---|--|---|---|---|---|--|--|--|---|--|--|---|--|--|--|--|---|--|---|--|--|---------------------------------------|--|---|---|---|---|--|--|--|--|---|--|---|---|---|--|---|--|---|---|---|--|---|--|--|--|--|---|
| 1 H Hydrogen 1.0079 2-1 | 3 Li Lithium 6.941 2-2 | 11 Na Sodium 22.990 2-8-1 | 19 K Potassium 39.098 2-8-8-1 | 37 Rb Rubidium 85.468 2-8-18-8-1 | 55 Cs Cesium 132.91 2-8-18-18-8-1 | 87 Fr Francium (223) -18-32-18-8-1 | 21 Sc Scandium 44.956 2-8-9-2 | 39 Y Yttrium 88.906 2-8-18-9-2 | 57-71 La Lanthanide | 72 Zr Zirconium 91.224 2-8-18-10-2 | 74 Hf Hafnium 178.49 2-8-18-32-10-2 | 104 Rf Rutherfordium (261) -18-32-32-10-2 | 22 Ti Titanium 47.887 2-8-10-2 | 40 Zr Zirconium 91.224 2-8-18-10-2 | 72 Hf Hafnium 178.49 2-8-18-32-10-2 | 104 Rf Rutherfordium (261) -18-32-32-10-2 | 23 V Vanadium 50.942 2-8-11-2 | 41 Nb Niobium 92.906 2-8-18-12-1 | 73 Ta Tantalum 180.95 2-8-18-32-11-2 | 105 Db Dubnium (262) -18-32-32-11-2 | 24 Cr Chromium 51.996 2-8-13-1 | 42 Mo Molybdenum 95.94 2-8-18-13-1 | 74 W Tungsten 183.84 2-8-18-32-12-2 | 106 Sg Seaborgium (266) -18-32-32-12-2 | 25 Mn Manganese 54.938 2-8-13-2 | 43 Tc Technetium (98) 2-8-18-14-1 | 75 Re Rhenium 186.21 2-8-18-32-13-2 | 107 Bh Bohrium (264) -18-32-32-13-2 | 26 Fe Iron 55.845 2-8-14-2 | 44 Ru Ruthenium 101.07 2-8-18-15-1 | 76 Os Osmium 190.23 2-8-18-32-14-2 | 108 Hs Hassium (277) -18-32-32-14-2 | 27 Co Cobalt 58.933 2-8-15-2 | 45 Rh Rhodium 102.91 2-8-18-16-1 | 77 Ir Iridium 192.22 2-8-18-32-15-2 | 109 Mt Meitnerium (268) -18-32-32-15-2 | 28 Ni Nickel 58.693 2-8-16-2 | 46 Pd Palladium 106.42 2-8-18-18 | 78 Pt Platinum 195.08 2-8-18-32-17-1 | 110 Uun Ununnilium (281) -18-32-32-17-1 | 29 Cu Copper 63.546 2-8-18-1 | 47 Ag Silver 107.87 2-8-18-18-1 | 79 Au Gold 196.97 2-8-18-32-18-1 | 111 Uuu Unununium (272) -18-32-32-18-1 | 30 Zn Zinc 65.39 2-8-18-2 | 48 Cd Cadmium 112.41 2-8-18-18-2 | 80 Hg Mercury 200.59 2-8-18-32-18-2 | 112 Uub Ununbium (285) -18-32-32-18-2 | 31 Ga Gallium 69.723 2-8-18-3 | 49 In Indium 114.82 2-8-18-18-3 | 81 Tl Thallium 204.38 2-8-18-32-18-3 | 113 Uut Ununtrium (284) -18-32-32-18-3 | 32 Ge Germanium 72.64 2-8-18-4 | 50 Sn Tin 118.71 2-8-18-18-4 | 82 Pb Lead 207.2 2-8-18-32-18-4 | 114 Uuq Ununquadium (289) -18-32-32-18-4 | 33 As Arsenic 74.922 2-8-18-5 | 51 Sb Antimony 121.76 2-8-18-18-5 | 83 Bi Bismuth 208.98 2-8-18-32-18-5 | 115 Uup Ununpentium (288) -18-32-32-18-5 | 34 Se Selenium 78.96 2-8-18-6 | 52 Te Tellurium 127.60 2-8-18-18-6 | 84 Po Polonium (209) 2-8-18-32-18-6 | 116 Uuh Ununhexium (291) -18-32-32-18-6 | 35 Br Bromine 79.904 2-8-18-7 | 53 I Iodine 126.90 2-8-18-18-7 | 85 At Astatine (210) 2-8-18-32-18-7 | 117 Uus Ununseptium (294) -18-32-32-18-7 | 36 Kr Krypton 83.80 2-8-18-8 | 54 Xe Xenon 131.29 2-8-18-18-8 | 86 Rn Radon (222) 2-8-18-32-18-8 | 118 Uuo Ununoctium (294) -18-32-32-18-8 |

| | | |
|------------------------|---------------------------|-------------|
| 14 IVA | 6 C | 12 IIB |
| Group IUPAC | Selected Oxidation States | Atomic Mass |
| Group CAS | Carbon | Carbon |
| Symbol | 12.011 | 12.011 |
| Name | Carbon | Carbon |
| Electron Configuration | 2-4 | 2-4 |

| Lanthanide | | Actinide | |
|---|---|---|---|
| 57 La Lanthanum 138.91 2-8-18-18-9-2 | 59 Pr Praseodymium 140.91 2-8-18-21-8-2 | 89 Ac Actinium (227) -18-32-18-9-2 | 87 Fr Francium (223) -18-32-18-8-1 |
| 58 Ce Cerium 140.12 2-8-18-20-9-2 | 60 Nd Neodymium 144.24 2-8-18-22-8-2 | 90 Th Thorium 232.04 -18-32-18-10-2 | 88 Ra Radium (226) -18-32-18-8-2 |
| 59 La Lanthanum 138.91 2-8-18-18-9-2 | 61 Pm Promethium (145) 2-8-18-23-8-2 | 91 Pa Protactinium 231.04 -18-32-20-9-2 | 89 Ac Actinium (227) -18-32-18-9-2 |
| 60 Nd Neodymium 144.24 2-8-18-22-8-2 | 62 Sm Samarium 150.36 2-8-18-24-9-2 | 92 U Uranium 238.03 -18-32-21-9-2 | 90 Th Thorium 232.04 -18-32-18-10-2 |
| 61 Pm Promethium (145) 2-8-18-23-8-2 | 63 Eu Europium 151.96 2-8-18-25-8-2 | 93 Np Neptunium (237) -18-32-25-8-2 | 91 Pa Protactinium 231.04 -18-32-20-9-2 |
| 62 Sm Samarium 150.36 2-8-18-24-9-2 | 64 Gd Gadolinium 157.25 2-8-18-25-9-2 | 94 Pu Plutonium (244) -18-32-24-9-2 | 92 U Uranium 238.03 -18-32-21-9-2 |
| 63 Eu Europium 151.96 2-8-18-25-8-2 | 65 Tb Terbium 158.93 2-8-18-27-8-2 | 95 Am Americium (243) -18-32-25-8-2 | 93 Np Neptunium (237) -18-32-25-8-2 |
| 64 Gd Gadolinium 157.25 2-8-18-25-9-2 | 66 Dy Dysprosium 162.50 2-8-18-28-8-2 | 96 Cm Curium (247) -18-32-25-9-2 | 94 Pu Plutonium (244) -18-32-24-9-2 |
| 65 Tb Terbium 158.93 2-8-18-27-8-2 | 67 Ho Holmium 164.93 2-8-18-29-8-2 | 97 Bk Berkelium (247) -18-32-28-8-2 | 95 Am Americium (243) -18-32-25-8-2 |
| 66 Dy Dysprosium 162.50 2-8-18-28-8-2 | 68 Er Erbium 167.26 2-8-18-30-8-2 | 98 Cf Californium (251) -18-32-28-8-2 | 96 Cm Curium (247) -18-32-25-9-2 |
| 67 Ho Holmium 164.93 2-8-18-29-8-2 | 69 Tm Thulium 168.93 2-8-18-31-8-2 | 99 Es Einsteinium (252) -18-32-28-8-2 | 97 Bk Berkelium (247) -18-32-28-8-2 |
| 68 Er Erbium 167.26 2-8-18-30-8-2 | 70 Yb Ytterbium 173.04 2-8-18-32-8-2 | 100 Fm Fermium (257) -18-32-30-8-2 | 98 Cf Californium (251) -18-32-28-8-2 |
| 69 Tm Thulium 168.93 2-8-18-31-8-2 | 71 Lu Lutetium 174.97 2-8-18-32-9-2 | 101 Md Mendelevium (258) -18-32-31-8-2 | 99 Es Einsteinium (252) -18-32-28-8-2 |
| 70 Yb Ytterbium 173.04 2-8-18-32-8-2 | 72 Lu Lutetium 174.97 2-8-18-32-9-2 | 102 No Nobelium (259) -18-32-31-8-2 | 100 Fm Fermium (257) -18-32-30-8-2 |
| 71 Lu Lutetium 174.97 2-8-18-32-9-2 | 73 Lu Lutetium 174.97 2-8-18-32-9-2 | 103 Lr Lawrencium (262) -18-32-31-8-2 | 101 Md Mendelevium (258) -18-32-31-8-2 |

| Electron Shells | |
|-----------------|-----|
| 1 | 2 |
| 2 | 8 |
| 3 | 18 |
| 4 | 32 |
| 5 | 50 |
| 6 | 72 |
| 7 | 98 |
| 8 | 118 |