est

HIGH SCHOOL

EST II
CHEMISTRY

Date:

Test Center:

Room Number:

Student's Name:

National ID:

EST ID:

Duration: 60 minutes

60 Multiple Choice Questions

Instructions:

- Place your answers on the answer sheet. Mark only one answer for each of the multiple-choice questions.
- Avoid guessing. Your answers should reflect your overall understanding of the subject matter.
- Scientific calculators are allowed.
- The periodic table is available at the end of the booklet as a reference.

Remarks

For all questions involving solutions and/or chemical equations, assume that the system is in pure water unless otherwise stated.

Part A

Directions:

- Each set of lettered choices below refers to the numbered statements or questions immediately following it.
- Select the one lettered choice that best fits each statement or answers each question, and then fill in the corresponding oval on the answer sheet.
- A choice may be used once, more than once, or not at all in each set.

Questions 1 – 3 refer to the following elements. Identify the element that matches each description:

A. Silicon
B. Nitrogen
C. Aluminum
D. Helium

Question 1. The element that has 2Z+1 as its mass number

Question 2. The element that is chemically stable in nature

Question 3. The element that has 4 valence electrons

Questions 4 − 7 refer to the following bond types. Match each description to the correct bond:

A. Single covalent bond
B. Double covalent bond
C. Triple covalent bond

Question 4. Consists of two pi bonds and one sigma bond

Question 5. Consists of one pi bond and one sigma bond

Question 6. Has the shortest bond length

Question 7. Is the strongest covalent bond

Questions 8 – 11 refer to the following ions. Match each ion to its correct name:

A. Br^-

B. BrO^-

C. BrO_2^-

D. BrO_3^-

E. BrO_4^-

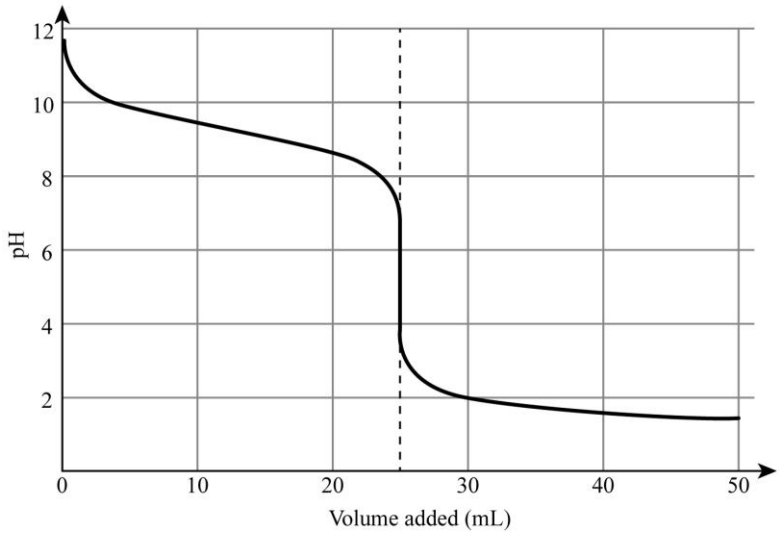
Question 8. Bromite

Question 9. Bromide

Question 10. Hypobromite

Question 11. Perbromate

Questions 12 − 14 refer to the titration curve below:



A. NH_3

B. NH_4^+

C. HCl

D. NH_4Cl

E. H_2O

Question 12. The titrant

Question 13. The titrate

Question 14. The reactants that remains in excess after the equivalence point

Questions 15 – 18 refer to the pictograms below. Match each description to the correct symbol:

A. **B.** **C.** **D.** **E.**

Question 15. May cause death or serious poisoning after brief exposure to a small amount

Question 16. May lead to serious health issues or is believed to pose significant health risks

Question 17. May explode and self-react in a confined place

Question 18. May self-ignite when exposed to water or air

Part B

Directions:

- Each of the questions or incomplete statements below is followed by five suggested answers or completions.
- Select the one that is best in each case, and then fill in the corresponding oval on the answer sheet.

Question 19. When 67.3 g of butanal (C_4H_8O) are mixed with 14.6 g of ethanoic acid ($C_2H_4O_2$), the mole percent of butanal in the mixture is:

A. 93.33%
B. 85.35%
C. 79.36%
D. 24.30%
E. 20.68%

Question 20. What mass of $CuSO_4.5H_2O$ should be weighed to obtain 35 g of $CuSO_4$ in 1 L?

A. 35 g
B. 53 g
C. 54.75 g
D. 159.61 g
E. 177.61 g

Questions 21 − 22 refer to the following reaction.

$$2\ NOCl \rightleftharpoons 2\ NO + Cl_2 \qquad K_c = 5.6 \times 10^{-6} \text{ at } 400\ K$$

Question 21. 0.035 mol of Cl_2 were released when 0.09 mol of NOCl was decomposed. The reaction quotient is:

A. 0.23
B. 0.43
C. 1.23
D. 8.58×10^{-3}
E. 5.85×10^{-3}

Question 22. At time t, the reaction will:

A. Shift in the reverse direction
B. Shift in the forward direction
C. Shift in both directions
D. Be at equilibrium
E. Not take place

Question 23. What is the main cause of corrosion in metals?

A. Reaction with oxygen and moisture
B. Exposure to sunlight
C. High temperatures
D. Acidic environment
E. Contact with other metals

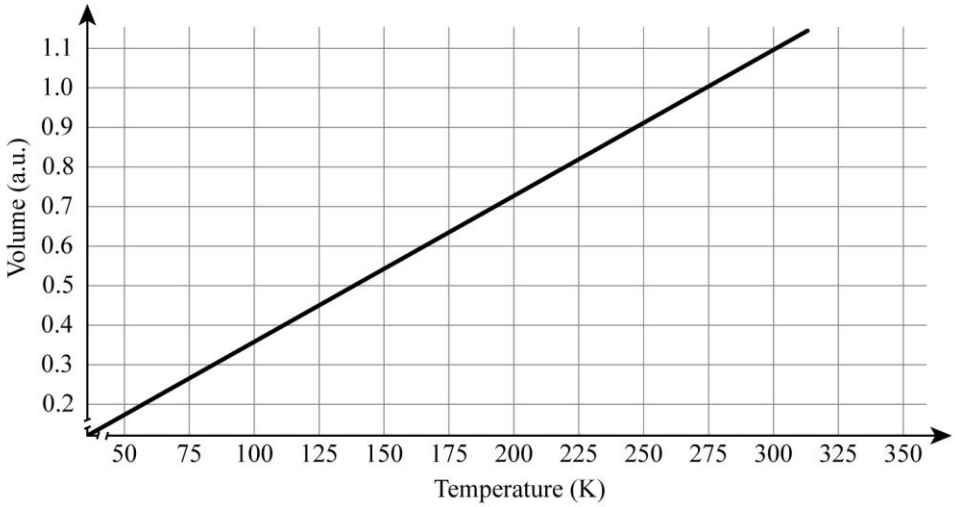
Question 24. The titration of 50 mL of 0.2 M NaOH with 0.1 M H_2SO_4 is performed. The volume of H_2SO_4 at the equivalence point is:

A. 12.5 mL
B. 25.0 mL
C. 37.5 mL
D. 50.0 mL
E. 100.0 mL

Question 25. Equal volumes of a 3.9×10^{-5} mol·L^{-1} magnesium hydroxide solution (Solution A) and a saturated magnesium hydroxide solution with $K_{sp} = 1.8 \times 10^{-11}$ (Solution B) are mixed. The final pH of the combined solution is:

A. 1.8
B. 5.0
C. 12.5
D. 11.0
E. 10.3

Questions 26 − 27 refer to the following graph.



Question 26. This graph represents:

A. Charle's Law
B. Boyle's Law
C. Gay-Lussac's Law
D. Henri's Law
E. Avogadro's Law

Question 27. What would be the volume at 568 K?

A. 1.50
B. 1.85
C. 2.05
D. 2.50
E. 3.00

Questions 28 − 29 refer to the bond energies table.

Bond	**C−H**	**C−Cl**	**Cl−Cl**	**O−H**	**H−Cl**	**C−O**
Bond Energy (kJ.mol^{-1})	415	330	240	460	340	358

Question 28. The enthalpy change for the reaction $CH_3OH + Cl_2 \rightarrow CH_2ClOH + HCl$ is:

A. −215 kJ.mol^{-1}
B. −15 kJ.mol^{-1}
C. −75 kJ.mol^{-1}
D. +60 kJ.mol^{-1}
E. +120 kJ.mol^{-1}

Question 29. The reaction is:

A. Strongly exothermic
B. Mildly exothermic
C. Athermic
D. Mildly endothermic
E. Strongly endothermic

Question 30. A 120 g piece of metal at 250°C is placed in 300 g of water at 20°C. The system reaches an equilibrium temperature of 28°C. What is the specific heat capacity of the metal?

A. 0.25 J.g^{-1}.°C^{-1}
B. 0.38 J.g^{-1}.°C^{-1}
C. 0.46 J.g^{-1}.°C^{-1}
D. 0.52 J.g^{-1}.°C^{-1}
E. 0.67 J.g^{-1}.°C^{-1}

Question 31. Given the following reaction:

$2\ SO_{2(g)} + O_{2(g)} \rightarrow 2\ SO_{3(g)} \quad \Delta H = -198.4$ kJ

Calculate the enthalpy change ΔH (in kJ) for the reaction: $SO_{2(g)} + \frac{1}{2} O_{2(g)} \rightarrow SO_{3(g)}$

A. −99.2 kJ
B. −148.4 kJ
C. −198.4 kJ
D. +99.2 kJ
E. +198.4 kJ

Question 32. A 2.3 L sealed container at 42.9°C contains 3.8 grams of $COCl_2$ and an unknown mass of argon gas. The total pressure in the container is 5.5 atm. The mass of argon gas present is:

A. 18 g
B. 15 g
C. 12 g
D. 9 g
E. 27 g

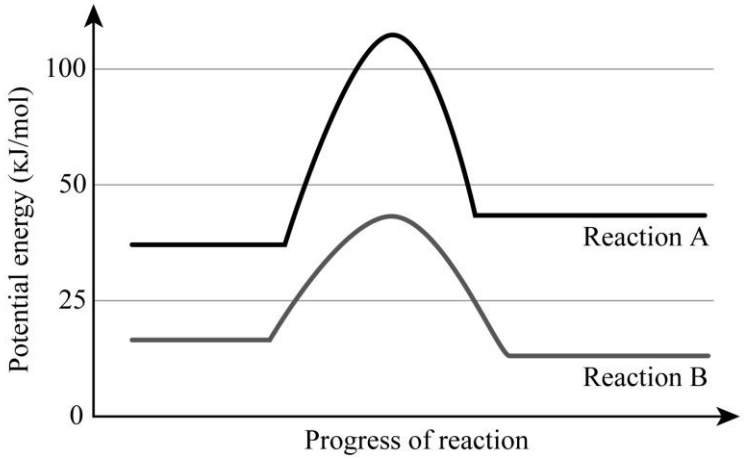
Question 33. Four cylinders each contain a gas mixture at a total pressure of 5 atm and a temperature of 320 K. Each cylinder contains exactly 2 moles of N_2 and 1 mole of another gas:

Cylinders	**A**	**B**	**C**	**D**
Mixture	$N_2 + SO_2$	$N_2 + NO_2$	$N_2 + PH_3$	$N_2 + Br_2$

Which cylinder contains the gas mixture with the highest density?

A. Cylinder A
B. Cylinder B
C. Cylinder C
D. Cylinder D
E. All cylinders have identical densities.

Question 34. Which reaction would proceed faster at the same temperature, and why?



A. Reaction A, because it has a lower activation energy.
B. Reaction B, because it has a lower activation energy.
C. Reaction A, because it is more exothermic.
D. Reaction B, because it is more endothermic.
E. They would proceed at the same rate.

Questions 35 − 36 refer to the experiments.

The reaction between hydrogen peroxide and iodide ions in acidic solution is:

$$H_2O_2 + 2\ I^- + 2\ H^+ \rightarrow 2\ H_2O + I_2$$

Experiment	$[H_2O_2]$	$[I^-]$	$[H^+]$	Initial Rate
1	0.10	0.10	0.10	2.0×10^{-4}
2	0.20	0.10	0.10	4.0×10^{-4}
3	0.10	0.20	0.10	4.0×10^{-4}
4	0.10	0.10	0.20	8.0×10^{-4}

Question 35. Using the data above, what is the correct rate law for this reaction?

A. Rate = $k[H_2O_2][I^-][H^+]$

B. Rate = $k[H_2O_2][I^-][H^+]^2$

C. Rate = $k[H_2O_2][I^-]^2[H^+]$

D. Rate = $k[H_2O_2]^2[I^-][H^+]$

E. Rate = $k[H_2O_2][H^+]$

Question 36. The value of the rate constant is:

A. $k = 0.5\ M^{-3}.s^{-1}$

B. $k = 1.0\ M^{-3}.s^{-1}$

C. $k = 2.0\ M^{-3}.s^{-1}$

D. $k = 4.0\ M^{-3}.s^{-1}$

E. $k = 8.0\ M^{-3}.s^{-1}$

Question 37. The total pressure in a 5 L container at 300 K is 4.5 atm. It contains 0.51 moles of NO_2 and 8.96 L of CO_2 at STP. The partial pressure of NO_2 and CO_2 are, respectively:

A. 2.52 atm; 1.98 atm
B. 2.04 atm; 2.46 atm
C. 1.50 atm; 3.00 atm
D. 3.00 atm; 1.50 atm
E. 2.25 atm; 2.25 atm

Question 38. Which of the following compounds is polar?

A. SF_6

B. OCS

C. IF_5

D. Both **A** and **C**

E. Both **B** and **C**

Question 39. Which of the following molecules exhibits dipole-dipole interactions as a significant intermolecular force?

A. NOCl
B. OCS
C. CO_2
D. CF_4
E. Both **A** and **B**

Question 40. The $[OH^-]$ of a solution increases by a factor of 100. How does the pH change?

A. It increases from 6 to 9.
B. It increases from 8 to 10.
C. It decreases from 8 to 6.
D. It decreases from 10 to 7.
E. It remains constant.

Question 41. An element belongs to period 4 and group 1. Which property is it most likely to exhibit?

A. High reactivity with water
B. Colorless gas at room temperature
C. Completely unreactive
D. Low melting point but nonmetallic
E. Strong acidity

Question 42. Why is sodium more reactive than lithium?

A. Sodium's outer electron is easier to remove.
B. Sodium has fewer protons.
C. Sodium has more neutrons.
D. Sodium has fewer electrons.
E. Sodium forms a different type of bond.

Question 43. Which trend increases from left to right across a period?

A. Atomic radius
B. Metallic character
C. Electronegativity
D. Reactivity of metals
E. Ionic radius of metals

Question 44. Which principle states that no two electrons in an atom can have the same set of quantum numbers?

A. Aufbau principle
B. Hund's rule
C. Pauli exclusion principle
D. Heinsberg uncertainty principle
E. Bohr's postulate

Question 45. Which of the following ions has the same electron configuration as neon?

A. Na^+
B. O^{2-}
C. F^-
D. Al^{3+}
E. All of the above

Question 46. What is the set of quantum numbers for the last electron in phosphorus?

A. n = 3, l = 1, m_l = 0, m_s = + ½
B. n = 3, l = 2, m_l = 1, m_s = – ½
C. n = 2, l = 1, m_l = 0, m_s = – ½
D. n = 3, l = 1, m_l = 1, m_s = + ½
E. n = 3, l = 0, m_l = 0, m_s = + ½

Question 47. Which molecule has a bond angle closest to 109.5°?

A. SF_2
B. SeH_2
C. ClF_3
D. PF_3
E. XeF_2

Question 48. A small amount of $AgNO_3$ is accidentally spilled into an unknown solution X, contaminating it. What could solution X be, and which separation method would best confirm and remove the contamination?

A. X: NaOH; Separation method: distillation
B. X: HCl; Separation method: filtration
C. X: $BaCl_2$; Separation method: decantation
D. X: NH_4OH; Separation method: centrifugation
E. X: K_2CrO_4; Separation method: distillation

Question 49. Fe_2O_3 is the chemical formula of the rust formed due to the exposure of iron to humidity. The ionic form of iron in rust is:

A. Fe^+
B. Fe^{2+}
C. Fe
D. Fe^{3-}
E. Fe^{3+}

Question 50. A student measures a mass repeatedly and gets very similar results each time, but they are all 0.5 g higher than the actual mass. Which statement is correct?

A. High accuracy, low precision
B. Low accuracy, high precision
C. High accuracy, high precision
D. Low accuracy, low precision
E. Cannot be determined

Question 51. Which of the following balanced chemical equations represents an oxidation–reduction reaction?

A. $HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$

B. $BaCl_{2(aq)} + Na_2SO_{4(aq)} \rightarrow BaSO_{4(s)} + 2\ NaCl_{(aq)}$

C. $Zn_{(s)} + CuSO_{4(aq)} \rightarrow ZnSO_{4(aq)} + Cu_{(s)}$

D. $NH_4Cl_{(s)} \rightarrow NH_{3(g)} + HCl_{(g)}$

E. $Na_2CO_{3(aq)} + 2\ HCl_{(aq)} \rightarrow 2\ NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$

Question 52. A student heats 1.74 g of pure NaN_3 and collects nitrogen gas with an actual yield of 75%. What mass of N_2 gas is actually obtained?

Given:

$$2\ NaN_{3(s)} \xrightarrow{Heat} 2\ Na_{(s)} + 3\ N_{2(g)}$$

A. 0.84 g
B. 0.90 g
C. 0.94 g
D. 1.12 g
E. 1.35 g

Question 53. A chemist mixes 1.80 mol of PCl_3 and 2.50 mol of Cl_2: $PCl_{3(l)} + Cl_{2(g)} \rightarrow PCl_{5(s)}$

Assuming complete reaction, what is the maximum number of molecules of PCl_5 that can form?

A. 1.08×10^{24}
B. 1.51×10^{24}
C. 2.17×10^{24}
D. 2.71×10^{24}
E. 3.01×10^{24}

Question 54. Consider the following reversible reaction at equilibrium in a closed container:

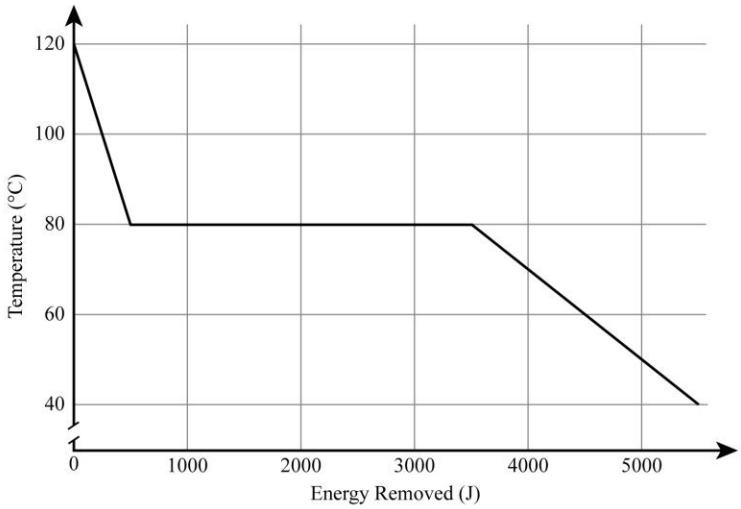
$$N_2O_{4(g)} \rightleftharpoons 2\ NO_{2(g)} \qquad \Delta H = +58\ kJ.mol^{-1}$$

Which of the following changes will shift the position of equilibrium in the reverse direction?

I. Increasing the temperature
II. Increasing the total pressure
III. Adding more NO_2 gas

A. **I** only
B. **II** only
C. **III** only
D. **II** and **III**
E. **I** and **III**

Question 55. The cooling curve of a 17 g substance is given below:



How much energy must be removed to completely condense 68 g of the same vapor, starting at its condensation temperature of 80°C?

A. 1500 J
B. 3000 J
C. 6000 J
D. 9000 J
E. 12000 J

Question 56. A 3.18 L sample of an ideal gas is at a pressure of 1.27 atm and a temperature of 363 K. The gas is heated at constant volume until its pressure increases to 2.49 atm. What is the final temperature of the gas?

A. 1132 K
B. 712 K
C. 467 K
D. 363 K
E. 185 K

Question 57. Which of the following will cause the largest decrease in the freezing point of water, assuming the same mass of each solute is dissolved in the same amount of water?

A. $C_6H_{12}O_6$
B. NaCl
C. $C_{12}H_{22}O_{11}$
D. NH_2CONH_2
E. Since they have the same mass, they have the same effect.

Questions 58 – 60 refer to the combustion analysis of an organic compound.

The combustion analysis of an organic compound shows it contains 54.5% C, 9.1% H, and 36.4% O by mass.

Question 58. What is the empirical formula of the compound based on the given percent composition?

A. CH_2O
B. C_2H_4O
C. $C_3H_6O_3$
D. C_2H_6O
E. CHO

Question 59. Which set of coefficients balances the complete combustion of the compound according to the following equation: $\_C_xH_yO_z + \_O_2 \rightarrow \_CO_2 + \_H_2O$?

A. 2, 5, 4, 4
B. 4, 4, 5, 2
C. 1, 3, 2, 2
D. 2, 2, 3, 1
E. 1, 2, 1, 1

Question 60. In an experiment, 12.0 g of the compound is combusted, and 17.6 g of CO_2 is collected. What is the percent yield of CO_2?

A. 24.1%
B. 37.3%
C. 59.9%
D. 73.3%
E. 91.2%

Periodic Table of the Elements

1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1 H Hydrogen 1.008																	2 He Helium 4.002602
3 Li Lithium 6.94	4 Be Beryllium 9.0121831											5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998403163	10 Ne Neon 20.1797
11 Na Sodium 22.98976928	12 Mg Magnesium 24.305											13 Al Aluminium 26.9815385	14 Si Silicon 28.085	15 P Phosphorus 30.973761998	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955908	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938044	26 Fe Iron 55.845	27 Co Cobalt 58.933194	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.921595	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90584	40 Zr Zirconium 91.224	41 Nb Niobium 92.90637	42 Mo Molybdenum 95.95	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.293
55 Cs Caesium 132.90545196	56 Ba Barium 137.327	57 - 71 Lanthanoids	72 Hf Hafnium 178.49	73 Ta Tantalum 180.94788	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.084	79 Au Gold 196.966569	80 Hg Mercury 200.592	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98040	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89 - 103 Actinoids	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Sg Seaborgium (269)	107 Bh Bohrium (270)	108 Hs Hassium (269)	109 Mt Meitnerium (278)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (282)	112 Cn Copernicium (285)	113 Nh Nihonium (286)	114 Fl Flerovium (289)	115 Mc Moscovium (289)	116 Lv Livermorium (293)	117 Ts Tennessine (294)	118 Og Oganesson (294)

57 La Lanthanum 138.90547	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90766	60 Nd Neodymium 144.242	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92535	66 Dy Dysprosium 162.500	67 Ho Holmium 164.93033	68 Er Erbium 167.259	69 Tm Thulium 168.93422	70 Yb Ytterbium 173.045	71 Lu Lutetium 174.9668
89 Ac Actinium (227)	90 Th Thorium 232.0377	91 Pa Protactinium 231.03588	92 U Uranium 238.02891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (266)