

Topics in the November 2012 Exam Paper for CHEM1612

Click on the links for resources on each topic.

2012-N-2:

- [Introduction to Chemical Energetics](#)
- [Solutions](#)
- [Acids and Bases](#)
- [Chemical Equilibrium](#)

2012-N-3:

- [Introduction to Chemical Energetics](#)

2012-N-4:

- [Gas Laws](#)

2012-N-5:

- [Chemical Equilibrium](#)

2012-N-6:

- [Acids and Bases](#)
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2012-N-7:

- [Introduction to Chemical Energetics](#)
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2012-N-8:

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2012-N-9:

- [Solutions](#)
- [Complexes](#)

2012-N-10:

- [Radiochemistry](#)

2012-N-11:

- [Redox Reactions and Introduction to Electrochemistry](#)

2012-N-12:

- [Redox Reactions and Introduction to Electrochemistry](#)
- [Chemical Kinetics](#)

2012-N-13:

- [Redox Reactions and Introduction to Electrochemistry](#)
- [Introduction to Colloids and Surface Chemistry](#)

2012-N-14:

- [Complexes](#)

2012-N-15:

- [Chemical Kinetics](#)

THE UNIVERSITY OF SYDNEY

CHEM1612 - CHEMISTRY 1B (PHARMACY)SECOND SEMESTER EXAMINATION**CONFIDENTIAL**

NOVEMBER 2012

TIME ALLOWED: THREE HOURS

GIVE THE FOLLOWING INFORMATION IN BLOCK LETTERS

FAMILY NAME		SID NUMBER	
OTHER NAMES		TABLE NUMBER	

INSTRUCTIONS TO CANDIDATES

- All questions are to be attempted. There are 22 pages of examinable material.
- Complete the examination paper in **INK**.
- Read each question carefully. Report the appropriate answer and show all relevant working in the space provided.
- The total score for this paper is 100. The possible score per page is shown in the adjacent tables.
- Each new short answer question begins with a ●.
- Only non-programmable, University-approved calculators may be used.
- Students are warned that credit may not be given, even for a correct answer, where there is insufficient evidence of the working required to obtain the solution.
- Numerical values required for any question, standard electrode reduction potentials, a Periodic Table and some useful formulas may be found on the separate data sheets.
- Page 24 is for rough work only.

OFFICIAL USE ONLY~~Multiple choice section~~

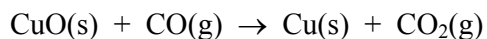
Pages	Marks	
	Max	Gained
2-9	28	

~~Short answer section~~

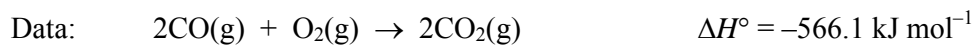
Page	Marks		Marker
	Max	Gained	
10	6		
11	4		
12	3		
13	4		
14	5		
15	7		
16	4		
17	7		
18	5		
19	6		
20	5		
21	6		
22	6		
23	4		
Total	72		
Check Total			

• Explain the following terms or concepts.	Marks 3
a) Second law of thermodynamics	
b) Vapour pressure	
c) Isoelectric point	
<p>• The electron transfer reaction between NADH and oxygen is a spontaneous reaction at 37 °C</p> $\text{NADH} + \frac{1}{2}\text{O}_2 + \text{H}^+ \rightarrow \text{NAD}^+ + \text{H}_2\text{O} \quad \Delta G = -220 \text{ kJ mol}^{-1}$ <p>When this reaction is carried out in solution in a test tube via direct mixing of NADH with dissolved oxygen, the reaction releases a significant amount of heat. However, when the reaction occurs in mitochondria during respiration, it produces very little heat. Explain why the heat evolved is much less in mitochondria.</p>	3

- Copper metal can be obtained by heating copper oxide, CuO, in the presence of carbon monoxide, CO, according to the following reaction.

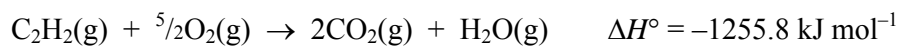


Calculate ΔH° for this reaction in kJ mol^{-1} .

**Marks****2**

Answer:

- Acetylene burns in air according to the following equation:



The $\Delta_f H^\circ$ of $\text{CO}_2\text{(g)} = -393.5 \text{ kJ mol}^{-1}$, $\Delta_f H^\circ$ of $\text{H}_2\text{O(l)} = -285.8 \text{ kJ mol}^{-1}$ and $\Delta_{\text{vap}} H^\circ$ of $\text{H}_2\text{O(l)} = +44.0 \text{ kJ mol}^{-1}$. What is $\Delta_f H^\circ$ of $\text{C}_2\text{H}_2\text{(g)}$?

2

Answer:

- A sample of gas is found to exert a pressure of 7.00×10^4 Pa when it is in a 3.00 L flask at 10.00 °C. Calculate the new volume if the pressure becomes 1.01×10^5 Pa and the temperature is unchanged.

Marks
3

Answer:

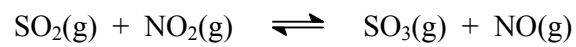
Calculate the new pressure if the volume becomes 2.00 L and the temperature is unchanged.

Answer:

Calculate the new pressure if the temperature is raised to 50.0 °C and the volume is unchanged, *i.e.* still 3.00 L.

Answer:

- Consider the following reaction.



An equilibrium mixture in a 1.00 L vessel was found to contain $[\text{SO}_2(\text{g})] = 0.800 \text{ M}$, $[\text{NO}_2(\text{g})] = 0.100 \text{ M}$, $[\text{SO}_3(\text{g})] = 0.600 \text{ M}$ and $[\text{NO}(\text{g})] = 0.400 \text{ M}$. If the volume and temperature are kept constant, what amount (in mol) of $\text{NO}(\text{g})$ needs to be added to the reaction vessel to give an equilibrium concentration of $\text{NO}_2(\text{g})$ of 0.300 M ?

Marks**4**

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

- Phenylketonuria is an inherited disorder in which phenylacetic acid, $C_6H_5CH_2COOH$, (simplified here to HPAC) accumulates in the blood. If untreated, it can cause mental retardation and death. A study of the acid shows that the pH of a 0.12 M HPAC solution is 2.60. What is the pK_a of phenylacetic acid?

Marks
3

Answer:

- The concentration of NaCl used in intravenous drips is 150 mM. Explain why this particular concentration is used and what the consequences would be for a patient if pure water were used instead.

2

- A calorimeter, consisting of an insulated coffee cup containing 50.0 g of water at 21.0 °C, has a total heat capacity of 9.4 J K^{-1} . When a 30.4 g sample of an alloy at 92.0 °C is placed into the calorimeter, the final temperature of the system is 31.2 °C. What is the specific heat capacity of the alloy?

Marks
3

Answer:

- At 21.0 °C, a solution of 18.26 g of a non-volatile, non-polar compound in 33.25 g of bromoethane, $\text{CH}_3\text{CH}_2\text{Br}$, has a vapour pressure of $4.42 \times 10^4 \text{ Pa}$. The vapour pressure of pure bromoethane at this temperature is $5.26 \times 10^4 \text{ Pa}$. What is the molar mass of the compound?

4

Answer:

- Buffer 1 is a solution containing 0.08 M NH_4Cl and 0.12 M NH_3 . Buffer 2 is a solution containing 0.15 M NH_4Cl and 0.05 M NH_3 . The acid dissociation constant of the ammonium ion is 5.50×10^{-10} . What are the pH values of each of the buffer solutions?

Marks**4**

Buffer 1 pH =

Buffer 2 pH =

Which buffer is better able to maintain a steady pH on the addition of small amounts of both a strong acid and strong base? Explain.

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.

- Order the following salts from lowest to highest molar solubility.

Marks
4

Salt	CuCl	Cd(IO ₃) ₂	BaSO ₄	Ag ₂ CrO ₄
K_{sp}	1.9×10^{-7}	2.3×10^{-8}	1.1×10^{-10}	2.6×10^{-12}

- Give the equilibrium concentration of Ni²⁺(aq) ions in a solution formed by dissolving 0.15 mol of NiCl₂ in 0.500 L of 2.00 M KCN solution.
The K_{stab} of [Ni(CN)₄]²⁻ = 1.7×10^{30} .

3

Answer:

- What mass of isotope would be initially required if a medical procedure needs 2.0 mg of ^{99m}Tc exactly 50 hours later? The half life of ^{99m}Tc is 6.0 hours.

Marks
2

Answer:

- Comment on the stability of the following nuclides, and the type of radioactive decay (if any) that they undergo.

3

- A galvanic cell consists of a Cr^{3+}/Cr half-cell with unknown $[\text{Cr}^{3+}]$ and a Ni^{2+}/Ni half-cell with $[\text{Ni}^{2+}] = 1.20 \text{ M}$. The electromotive force of the cell at 25°C was measured to be 0.55 V . What is the concentration of Cr^{3+} in the Cr^{3+}/Cr half-cell?

Marks
6

Answer:

Calculate the equilibrium constant of the reaction at 25°C .

Answer:

Calculate the standard Gibbs free energy of the reaction at 25°C .

Answer:

Express the overall reaction in the shorthand voltaic cell notation.

- A strip of copper and a strip of zinc are embedded in a lemon, and are connected by wires to a voltmeter; a voltage is generated and can be read at the voltmeter. What chemical reactions are occurring that lead to the generation of current?

Marks
3

Assuming there are no losses in the circuit and the conditions are similar to standard, what voltage can be read at the voltmeter?

- The rate constant of a polymer cross-linking reaction was established as a function of temperature. How can we demonstrate that the kinetics of this reaction follow Arrhenius behaviour? If it does follow Arrhenius behaviour, how can we derive the activation energy for the reaction and the pre-exponential factor A ?

2

- A 20.0 mL sample of 0.121 M Fe^{2+} in an acid solution was used to titrate 23.5 mL of a KMnO_4 solution of unknown concentration. Write the balanced redox reaction that occurs in solution upon titration, and calculate the molarity of the KMnO_4 solution.

Marks**4**

Answer:

- Why do phospholipids self-assemble in solution, what structures do they form, and why are they relevant to cell biology?

2

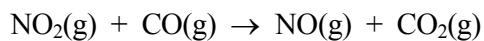
- Draw all stereoisomers of the complex ion of $[\text{CoCl}_2(\text{en})_2]\text{Cl}$. Label the non-optically active isomer with its systematic name.
(en = ethylenediamine = 1,2-ethanediamine = $\text{NH}_2\text{CH}_2\text{CH}_2\text{NH}_2$)

Marks
4

- What is a dative bond and does it differ from a covalent bond? Use examples from coordination chemistry and elsewhere to illustrate your answer.

2

- The major pollutants emitted by cars, NO(g), CO(g), NO₂(g) and CO₂(g), can react according to the following equation.



The following rate data were collected at 215 °C.

Experiment	[NO ₂] ₀ (M)	[CO] ₀ (M)	Initial rate (d[NO ₂]/dt, M s ⁻¹)
1	0.263	0.826	1.44 × 10 ⁻⁵
2	0.263	0.413	1.44 × 10 ⁻⁵
3	0.526	0.413	5.76 × 10 ⁻⁵

Determine the rate law for the reaction.

Suggest a possible mechanism for the reaction based on the form of the rate law. Explain your answer.

Marks**4**

CHEM1612 - CHEMISTRY 1B (PHARMACY)**DATA SHEET***Physical constants*Avogadro constant, $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$ Faraday constant, $F = 96485 \text{ C mol}^{-1}$ Planck constant, $h = 6.626 \times 10^{-34} \text{ J s}$ Speed of light in vacuum, $c = 2.998 \times 10^8 \text{ m s}^{-1}$ Rydberg constant, $E_R = 2.18 \times 10^{-18} \text{ J}$ Boltzmann constant, $k_B = 1.381 \times 10^{-23} \text{ J K}^{-1}$ Permittivity of a vacuum, $\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ J}^{-1} \text{ m}^{-1}$ Gas constant, $R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$
 $= 0.08206 \text{ L atm K}^{-1} \text{ mol}^{-1}$ Charge of electron, $e = 1.602 \times 10^{-19} \text{ C}$ Mass of electron, $m_e = 9.1094 \times 10^{-31} \text{ kg}$ Mass of proton, $m_p = 1.6726 \times 10^{-27} \text{ kg}$ Mass of neutron, $m_n = 1.6749 \times 10^{-27} \text{ kg}$ *Properties of matter*

Volume of 1 mole of ideal gas at 1 atm and 25 °C = 24.5 L

Volume of 1 mole of ideal gas at 1 atm and 0 °C = 22.4 L

Density of water at 298 K = 0.997 g cm⁻³*Conversion factors*

1 atm = 760 mmHg = 101.3 kPa

1 Ci = 3.70×10^{10} Bq

0 °C = 273 K

1 Hz = 1 s⁻¹1 L = 10⁻³ m³1 tonne = 10³ kg1 Å = 10⁻¹⁰ m1 W = 1 J s⁻¹1 eV = 1.602×10^{-19} J*Decimal fractions*

Fraction	Prefix	Symbol
10 ⁻³	milli	m
10 ⁻⁶	micro	μ
10 ⁻⁹	nano	n
10 ⁻¹²	pico	p

Decimal multiples

Multiple	Prefix	Symbol
10 ³	kilo	k
10 ⁶	mega	M
10 ⁹	giga	G

CHEM1612 - CHEMISTRY 1B (PHARMACY)*Standard Reduction Potentials, E°*

Reaction	E° / V
$\text{Co}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Co}^{2+}(\text{aq})$	+1.82
$\text{Ce}^{4+}(\text{aq}) + \text{e}^- \rightarrow \text{Ce}^{3+}(\text{aq})$	+1.72
$\text{MnO}_4^-(\text{aq}) + 8\text{H}^+(\text{aq}) + 5\text{e}^- \rightarrow \text{Mn}^{2+}(\text{aq}) + 4\text{H}_2\text{O}$	+1.51
$\text{Au}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Au}(\text{s})$	+1.50
$\text{Cr}_2\text{O}_7^{2-}(\text{aq}) + 14\text{H}^+(\text{aq}) + 6\text{e}^- \rightarrow 2\text{Cr}^{3+}(\text{g}) + 7\text{H}_2\text{O}$	+1.36
$\text{Cl}_2(\text{g}) + 2\text{e}^- \rightarrow 2\text{Cl}^-(\text{aq})$	+1.36
$\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$	+1.23
$\text{Pt}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Pt}(\text{s})$	+1.18
$\text{MnO}_2(\text{s}) + 4\text{H}^+(\text{aq}) + \text{e}^- \rightarrow \text{Mn}^{3+} + 2\text{H}_2\text{O}$	+0.96
$\text{NO}_3^-(\text{aq}) + 4\text{H}^+(\text{aq}) + 3\text{e}^- \rightarrow \text{NO}(\text{g}) + 2\text{H}_2\text{O}$	+0.96
$\text{Pd}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Pd}(\text{s})$	+0.92
$\text{Ag}^+(\text{aq}) + \text{e}^- \rightarrow \text{Ag}(\text{s})$	+0.80
$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{aq})$	+0.77
$\text{Cu}^+(\text{aq}) + \text{e}^- \rightarrow \text{Cu}(\text{s})$	+0.53
$\text{Cu}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cu}(\text{s})$	+0.34
$\text{Sn}^{4+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Sn}^{2+}(\text{aq})$	+0.15
$2\text{H}^+(\text{aq}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g})$	0 (by definition)
$\text{Fe}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Fe}(\text{s})$	-0.04
$\text{Pb}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Pb}(\text{s})$	-0.13
$\text{Sn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Sn}(\text{s})$	-0.14
$\text{Ni}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ni}(\text{s})$	-0.24
$\text{Cd}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cd}(\text{s})$	-0.40
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$	-0.44
$\text{Cr}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Cr}(\text{s})$	-0.74
$\text{Zn}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Zn}(\text{s})$	-0.76
$2\text{H}_2\text{O} + 2\text{e}^- \rightarrow \text{H}_2(\text{g}) + 2\text{OH}^-(\text{aq})$	-0.83
$\text{Cr}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Cr}(\text{s})$	-0.89
$\text{Al}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Al}(\text{s})$	-1.68
$\text{Sc}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Sc}(\text{s})$	-2.09
$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mg}(\text{s})$	-2.36
$\text{Na}^+(\text{aq}) + \text{e}^- \rightarrow \text{Na}(\text{s})$	-2.71
$\text{Ca}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Ca}(\text{s})$	-2.87
$\text{Li}^+(\text{aq}) + \text{e}^- \rightarrow \text{Li}(\text{s})$	-3.04

CHEM1612 - CHEMISTRY 1B (PHARMACY)

Useful formulas

<p>Quantum Chemistry</p> $E = h\nu = hc/\lambda$ $\lambda = h/mv$ $E = -Z^2 E_R(1/n^2)$ $\Delta x \cdot \Delta(mv) \geq h/4\pi$ $q = 4\pi r^2 \times 5.67 \times 10^{-8} \times T^4$ $T\lambda = 2.898 \times 10^6 \text{ K nm}$	<p>Electrochemistry</p> $\Delta G^\circ = -nFE^\circ$ $\text{Moles of } e^- = It/F$ $E = E^\circ - (RT/nF) \times 2.303 \log Q$ $= E^\circ - (RT/nF) \times \ln Q$ $E^\circ = (RT/nF) \times 2.303 \log K$ $= (RT/nF) \times \ln K$ $E = E^\circ - \frac{0.0592}{n} \log Q \text{ (at } 25^\circ \text{C)}$
<p>Acids and Bases</p> $\text{p}K_w = \text{pH} + \text{pOH} = 14.00$ $\text{p}K_w = \text{p}K_a + \text{p}K_b = 14.00$ $\text{pH} = \text{p}K_a + \log \{ [A^-] / [HA] \}$	<p>Gas Laws</p> $PV = nRT$ $(P + n^2 a/V^2)(V - nb) = nRT$ $E_k = \frac{1}{2}mv^2$
<p>Radioactivity</p> $t_{1/2} = \ln 2 / \lambda$ $A = \lambda N$ $\ln(N_0/N_t) = \lambda t$ $^{14}\text{C age} = 8033 \ln(A_0/A_t) \text{ years}$	<p>Kinetics</p> $t_{1/2} = \ln 2 / k$ $k = Ae^{-E_a/RT}$ $\ln[A] = \ln[A]_0 - kt$ $\ln \frac{k_2}{k_1} = \frac{E_a}{R} \left(\frac{1}{T_1} - \frac{1}{T_2} \right)$
<p>Mathematics</p> $\text{If } ax^2 + bx + c = 0, \text{ then } x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$ $\ln x = 2.303 \log x$ $\text{Area of circle} = \pi r^2$ $\text{Surface area of sphere} = 4\pi r^2$ $\text{Volume of sphere} = \frac{4}{3} \pi r^3$	<p>Thermodynamics & Equilibrium</p> $\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$ $\Delta G = \Delta G^\circ + RT \ln Q$ $\Delta G^\circ = -RT \ln K$ $\Delta_{\text{univ}} S^\circ = R \ln K$ $\ln \frac{K_2}{K_1} = \frac{-\Delta H^\circ}{R} \left(\frac{1}{T_2} - \frac{1}{T_1} \right)$
<p>Miscellaneous</p> $A = -\log \frac{I}{I_0}$ $A = \epsilon cl$ $E = -A \frac{e^2}{4\pi\epsilon_0 r} N_A$	<p>Colligative Properties & Solutions</p> $\Pi = cRT$ $P_{\text{solution}} = X_{\text{solvent}} \times P^\circ_{\text{solvent}}$ $c = kp$ $\Delta T_f = K_f m$ $\Delta T_b = K_b m$

PERIODIC TABLE OF THE ELEMENTS

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 HYDROGEN H 1.008																	2 HELIUM He 4.003
3 LITHIUM Li 6.941	4 BERYLLIUM Be 9.012											5 BORON B 10.81	6 CARBON C 12.01	7 NITROGEN N 14.01	8 OXYGEN O 16.00	9 FLUORINE F 19.00	10 NEON Ne 20.18
11 SODIUM Na 22.99	12 MAGNESIUM Mg 24.31											13 ALUMINIUM Al 26.98	14 SILICON Si 28.09	15 PHOSPHORUS P 30.97	16 SULFUR S 32.07	17 CHLORINE Cl 35.45	18 ARGON Ar 39.95
19 POTASSIUM K 39.10	20 CALCIUM Ca 40.08	21 SCANDIUM Sc 44.96	22 TITANIUM Ti 47.88	23 VANADIUM V 50.94	24 CHROMIUM Cr 52.00	25 MANGANESE Mn 54.94	26 IRON Fe 55.85	27 COBALT Co 58.93	28 NICKEL Ni 58.69	29 COPPER Cu 63.55	30 ZINC Zn 65.39	31 GALLIUM Ga 69.72	32 GERMANIUM Ge 72.59	33 ARSENIC As 74.92	34 SELENIUM Se 78.96	35 BROMINE Br 79.90	36 KRYPTON Kr 83.80
37 RUBIDIUM Rb 85.47	38 STRONTIUM Sr 87.62	39 YTRIUM Y 88.91	40 ZIRCONIUM Zr 91.22	41 NIOBIUM Nb 92.91	42 MOLYBDENUM Mo 95.94	43 TECHNETIUM Tc [98.91]	44 RUTHENIUM Ru 101.07	45 RHODIUM Rh 102.91	46 PALLADIUM Pd 106.4	47 SILVER Ag 107.87	48 CADMIUM Cd 112.40	49 INDIUM In 114.82	50 TIN Sn 118.69	51 ANTIMONY Sb 121.75	52 TELLURIUM Te 127.60	53 IODINE I 126.90	54 XENON Xe 131.30
55 CAESIUM Cs 132.91	56 BARIUM Ba 137.34	57-71	72 HAFNIUM Hf 178.49	73 TANTALUM Ta 180.95	74 TUNGSTEN W 183.85	75 RHENIUM Re 186.2	76 OSMIUM Os 190.2	77 IRIDIUM Ir 192.22	78 PLATINUM Pt 195.09	79 GOLD Au 196.97	80 MERCURY Hg 200.59	81 THALLIUM Tl 204.37	82 LEAD Pb 207.2	83 BISMUTH Bi 208.98	84 POLONIUM Po [210.0]	85 ASTATINE At [210.0]	86 RADON Rn [222.0]
87 FRANCIUM Fr [223.0]	88 RADIUM Ra [226.0]	89-103	104 RUTHERFORDIUM Rf [261]	105 DUBNIUM Db [262]	106 SEABORGIUM Sg [266]	107 BOHRIUM Bh [262]	108 HASSIUM Hs [265]	109 MEITNERIUM Mt [266]	110 DARMSTADTIUM Ds [271]	111 ROENTGENIUM Rg [272]	112 COPERNICIUM Cn [283]						

LANTHANOID S	57 LANTHANUM La 138.91	58 CERIUM Ce 140.12	59 PRASEODYMIUM Pr 140.91	60 NEODYMIUM Nd 144.24	61 PROMETHIUM Pm [144.9]	62 SAMARIUM Sm 150.4	63 EUROPIUM Eu 151.96	64 GADOLINIUM Gd 157.25	65 TERBIUM Tb 158.93	66 DYSPROSIUM Dy 162.50	67 HOLMIUM Ho 164.93	68 ERBIUM Er 167.26	69 THULIUM Tm 168.93	70 YTTERBIUM Yb 173.04	71 LUTETIUM Lu 174.97
	ACTINOIDS	89 ACTINIUM Ac [227.0]	90 THORIUM Th 232.04	91 PROTACTINIUM Pa [231.0]	92 URANIUM U 238.03	93 NEPTUNIUM Np [237.0]	94 PLUTONIUM Pu [239.1]	95 AMERICIUM Am [243.1]	96 CURIUM Cm [247.1]	97 BERKELIUM Bk [247.1]	98 CALIFORNIUM Cf [252.1]	99 EINSTEINIUM Es [252.1]	100 FERMIUM Fm [257.1]	101 MENDELEVIUM Md [256.1]	102 NOBELIUM No [259.1]