

**Topics in the November 2013 Exam Paper for CHEM1612**

Click on the links for resources on each topic.

2013-N-2:

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

2013-N-3:

- [Introduction to Chemical Energetics](#)
- [Solubility](#)

2013-N-4:

- [Gas Laws](#)

2013-N-5:

- [Chemical Equilibrium](#)

2013-N-6:

- [Introduction to Chemical Energetics](#)
- [Solutions](#)

2013-N-7:

- [Chemical Equilibrium](#)
- [Introduction to Chemical Energetics](#)

2013-N-8:

- [Introduction to Chemical Energetics](#)
- [Chemical Equilibrium](#)

2013-N-9:

- [Radiochemistry](#)
- [Acids and Bases](#)

2013-N-10:

- [Complexes](#)

2013-N-11:

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

2013-N-12:

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

2013-N-13:

- [Chemical Kinetics](#)

2218(a)

# THE UNIVERSITY OF SYDNEY

## CHEM1612 - CHEMISTRY 1B (PHARMACY)

### SECOND SEMESTER EXAMINATION

#### CONFIDENTIAL

NOVEMBER 2013

TIME ALLOWED: THREE HOURS

GIVE THE FOLLOWING INFORMATION IN BLOCK LETTERS

<b>FAMILY NAME</b>		<b>SID NUMBER</b>	
<b>OTHER NAMES</b>		<b>TABLE NUMBER</b>	

#### OFFICIAL USE ONLY

#### INSTRUCTIONS TO CANDIDATES

- All questions are to be attempted. There are 20 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.
- Pages 16, 20 and 24 are for rough work only.

#### ~~Multiple choice section~~

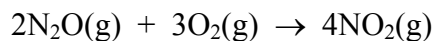
			Marks	
Pages	Max	Gained		
2-9	30			

#### Short answer section

Page	Marks		Marker
	Max	Gained	
10	5		
11	6		
12	5		
13	5		
14	5		
15	5		
17	4		
18	9		
19	9		
21	7		
22	6		
23	4		
Total	70		
Check Total			

<ul style="list-style-type: none"><li>• Explain the following terms or concepts.</li></ul>	<b>Marks</b> <b>3</b>
Third law of thermodynamics	
Osmotic pressure	
Lewis base	
<ul style="list-style-type: none"><li>• The specific heat capacity of water at 0 °C is undefined. Explain why this is so.</li></ul>	<b>2</b>

- Consider the following reaction:



Calculate  $\Delta G^\circ$  for this reaction given the following data.



**Marks**  
**3**

Answer:

- Calculate the molar solubility of silver sulfide,  $\text{Ag}_2\text{S}$ , given that  $K_{\text{sp}}$  is  $8 \times 10^{-51}$  at  $25^\circ\text{C}$ .

**3**

Answer:

**Marks**  
**5**

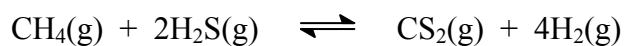
- Calcium carbide,  $\text{CaC}_2$ , reacts with water to produce a gas and a solution containing  $\text{OH}^-$  ions. A sample of  $\text{CaC}_2$  was treated with excess water and the resulting gas was collected in an evacuated 5.00 L glass bulb. At the completion of the reaction, the pressure inside the bulb was  $1.00 \times 10^5$  Pa at a temperature of 26.8 °C. Calculate the amount (in mol) of the gas produced.

Answer:

Given that the mass of the gas collected was 5.21 g, show that the molar mass of the gas is  $25.9 \text{ g mol}^{-1}$ .

Suggest a molecular formula for the gas and write a balanced equation for the reaction that occurred.

- Methane, CH<sub>4</sub>, reacts with hydrogen sulfide, H<sub>2</sub>S, according to the following equilibrium:



In an experiment 1.00 mol of CH<sub>4</sub>, 2.00 mol of H<sub>2</sub>S, 1.00 mol of CS<sub>2</sub> and 2.00 mol of H<sub>2</sub> are mixed in a 250 mL vessel at 960 °C. At this temperature,  $K_c = 0.034$  (based on a standard state of 1 mol L<sup>-1</sup>).

Calculate the reaction quotient,  $Q$ , and hence predict in which direction the reaction will proceed to reach equilibrium? Explain your answer.

**Marks**  
**5**

Show that the system is at equilibrium when  $[\text{CH}_4(\text{g})] = 5.56 \text{ M}$ .

**Marks**  
**2**

- Isooctane, an important constituent of petrol, has a boiling point of 99.3 °C and a standard enthalpy of vaporisation of 37.7 kJ mol<sup>-1</sup>. What is  $\Delta S^\circ$  (in J K<sup>-1</sup> mol<sup>-1</sup>) for the vaporisation of isooctane?

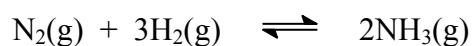
Answer:

**3**

- An aqueous solution with a volume of 10.0 mL contains 0.025 g of a purified protein of unknown molecular weight. The osmotic pressure of the solution was measured in an osmometer to be 0.0036 atm at 20.0 °C. Assuming ideal behaviour and no dissociation of the protein, estimate its molar mass in g mol<sup>-1</sup>.

Answer:

- Ammonia is synthesised according to the following reaction.

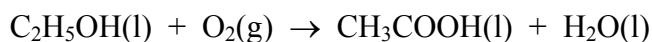


At 500 °C this reaction has a  $K_c$  of  $6.0 \times 10^{-2}$ .  $\Delta H^\circ$  for this reaction is  $-92 \text{ kJ mol}^{-1}$ . Calculate the value of  $K_c$  at 200 °C.

**Marks**  
**3**

Answer:

- Good wine will turn to vinegar if it is left exposed to air because the alcohol is oxidised to acetic acid. The equation for the reaction is



Calculate  $\Delta S^\circ$  for this reaction in  $\text{J K}^{-1} \text{ mol}^{-1}$ .

Data:	$\Delta S^\circ$ ( $\text{J K}^{-1} \text{ mol}^{-1}$ )
$\text{C}_2\text{H}_5\text{OH}(\text{l})$	161
$\text{O}_2(\text{g})$	205.0
$\text{CH}_3\text{COOH}(\text{l})$	160
$\text{H}_2\text{O}(\text{l})$	69.96

**2**

Answer:



**Marks**  
**4**

- One of the most important reactions in living cells is the splitting of adenosine triphosphate (ATP) to adenosine diphosphate (ADP) and free phosphate ( $P_i$ ):



Based on a standard state of 1 M, the value of  $\Delta G^\circ$  for this reaction at 37 °C is  $-33 \text{ kJ mol}^{-1}$ . Calculate the value of the equilibrium constant for the reaction at this temperature.

Answer:

The following concentrations are typical in a living cell.

ATP: 5 mM	ADP: 0.1 mM	$P_i$ : 5 mM
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Under these conditions, calculate the energy per mole that is available from the splitting of ATP.

Answer:

- Balance the following nuclear reactions and name the decay process occurring.

**Marks**  
**6**

Equation	Name of decay process
${}^{15}_8\text{O} \rightarrow {}^{15}_7\text{N} + \square$	
${}^{238}_{92}\text{U} \rightarrow {}^{234}_{90}\text{Th} + \square$	
${}^{40}_{19}\text{K} + \square \rightarrow {}^{40}_{18}\text{Ar}$	

- What amount of NaOH (in mol) needs to be added to 250 mL of 0.10 M acetic acid to give a solution with a pH of 5.00? The  $pK_a$  of acetic acid is 4.76.

**3**

Answer:
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- Complete the following table.

**Marks**  
**9**

Coordination compound	Oxidation number of transition metal	Number of <i>d</i> electrons around transition metal	Arrangement of <i>d</i> electrons
$K_2[PtCl_4]$			
$Na[MnO_4]$			
$(NH_4)_2[CoCl_4]$			
$[Cr(NH_3)_5(OH_2)]Cl_3$			

Identify one paramagnetic and one diamagnetic species from the above table.

Paramagnetic:	Diamagnetic:
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**THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY.**

**Marks**  
**3**

- What is the electrochemical potential of the following cell at 25 °C?



Answer:

- Calculate the mass of aluminium which can be produced with the same quantity of electricity that is used to produce 1.00 kg of copper metal.

**2**

Answer:

- Explain why Na(s) cannot be obtained by the electrolysis of aqueous NaCl solutions.

**2**

**Marks**  
**6**

- Give a brief definition or explanation of the following concepts in colloid science.

double layer

counter ion

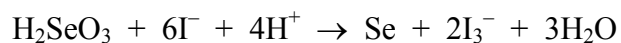
isoelectric point

zeta potential

flocculation

electrokinetic mobility

- The following reaction is run from 4 different starting positions.



Experiment	Initial $[\text{H}_2\text{SeO}_3]$ (mol L <sup>-1</sup> )	Initial $[\text{I}^-]$ (mol L <sup>-1</sup> )	Initial $[\text{H}^+]$ (mol L <sup>-1</sup> )	Initial rate of increase of $[\text{I}_3^-]$ (mol L <sup>-1</sup> s <sup>-1</sup> )
1	0.100	0.100	0.100	1.000
2	0.100	0.075	0.100	0.422
3	0.075	0.100	0.100	0.750
4	0.100	0.075	0.075	0.237

Determine the rate law for the reaction.

What is the value of the rate constant?

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<sup>-3</sup>*Conversion factors*

1 atm = 760 mmHg = 101.3 kPa

1 Ci = 3.70 × 10<sup>10</sup> Bq

0 °C = 273 K

1 Hz = 1 s<sup>-1</sup>1 L = 10<sup>-3</sup> m<sup>3</sup>1 tonne = 10<sup>3</sup> kg1 Å = 10<sup>-10</sup> m1 W = 1 J s<sup>-1</sup>1 eV = 1.602 × 10<sup>-19</sup> J*Decimal fractions*

Fraction	Prefix	Symbol
10 <sup>-3</sup>	milli	m
10 <sup>-6</sup>	micro	μ
10 <sup>-9</sup>	nano	n
10 <sup>-12</sup>	pico	p

*Decimal multiples*

Multiple	Prefix	Symbol
10 <sup>3</sup>	kilo	k
10 <sup>6</sup>	mega	M
10 <sup>9</sup>	giga	G
10 <sup>12</sup>	tera	T

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

Reaction	$E^\circ / \text{V}$
$\text{Co}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Co}^{2+}(\text{aq})$	+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><b>Quantum Chemistry</b></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><b>Electrochemistry</b></p> $\Delta G^\circ = -nFE^\circ$ <p>Moles of <math>e^- = It/F</math></p> $E = E^\circ - (RT/nF) \times 2.303 \log Q$ $= E^\circ - (RT/nF) \times \ln Q$ $E^\circ = (RT/nF) \times 2.303 \log K$ $= (RT/nF) \times \ln K$ $E = E^\circ - \frac{0.0592}{n} \log Q \text{ (at } 25^\circ\text{C)}$
<p><b>Acids and Bases</b></p> $pK_w = \text{pH} + \text{pOH} = 14.00$ $pK_w = \text{p}K_a + \text{p}K_b = 14.00$ $\text{pH} = \text{p}K_a + \log \{ [A^-] / [HA] \}$	<p><b>Gas Laws</b></p> $PV = nRT$ $(P + n^2a/V^2)(V - nb) = nRT$ $E_k = \frac{1}{2}mv^2$
<p><b>Radioactivity</b></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><b>Kinetics</b></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><b>Mathematics</b></p> <p>If <math>ax^2 + bx + c = 0</math>, then <math>x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}</math></p> $\ln x = 2.303 \log x$ <p>Area of circle = <math>\pi r^2</math></p> <p>Surface area of sphere = <math>4\pi r^2</math></p> <p>Volume of sphere = <math>\frac{4}{3} \pi r^3</math></p>	<p><b>Thermodynamics &amp; Equilibrium</b></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><b>Miscellaneous</b></p> $A = -\log \frac{I}{I_0}$ $A = \epsilon cl$ $E = -A \frac{e^2}{4\pi\epsilon_0 r} N_A$	<p><b>Colligative Properties &amp; Solutions</b></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 <b>H</b> 1.008																	2 HELIUM <b>He</b> 4.003
3 LITHIUM <b>Li</b> 6.941	4 BERYLLIUM <b>Be</b> 9.012											5 BORON <b>B</b> 10.81	6 CARBON <b>C</b> 12.01	7 NITROGEN <b>N</b> 14.01	8 OXYGEN <b>O</b> 16.00	9 FLUORINE <b>F</b> 19.00	10 NEON <b>Ne</b> 20.18
11 SODIUM <b>Na</b> 22.99	12 MAGNESIUM <b>Mg</b> 24.31											13 ALUMINIUM <b>Al</b> 26.98	14 SILICON <b>Si</b> 28.09	15 PHOSPHORUS <b>P</b> 30.97	16 SULFUR <b>S</b> 32.07	17 CHLORINE <b>Cl</b> 35.45	18 ARGON <b>Ar</b> 39.95
19 POTASSIUM <b>K</b> 39.10	20 CALCIUM <b>Ca</b> 40.08	21 SCANDIUM <b>Sc</b> 44.96	22 TITANIUM <b>Ti</b> 47.88	23 VANADIUM <b>V</b> 50.94	24 CHROMIUM <b>Cr</b> 52.00	25 MANGANESE <b>Mn</b> 54.94	26 IRON <b>Fe</b> 55.85	27 COBALT <b>Co</b> 58.93	28 NICKEL <b>Ni</b> 58.69	29 COPPER <b>Cu</b> 63.55	30 ZINC <b>Zn</b> 65.39	31 GALLIUM <b>Ga</b> 69.72	32 GERMANIUM <b>Ge</b> 72.59	33 ARSENIC <b>As</b> 74.92	34 SELENIUM <b>Se</b> 78.96	35 BROMINE <b>Br</b> 79.90	36 KRYPTON <b>Kr</b> 83.80
37 RUBIDIUM <b>Rb</b> 85.47	38 STRONTIUM <b>Sr</b> 87.62	39 YTTRIUM <b>Y</b> 88.91	40 ZIRCONIUM <b>Zr</b> 91.22	41 NIOBIUM <b>Nb</b> 92.91	42 MOLYBDENUM <b>Mo</b> 95.94	43 TECHNETIUM <b>Tc</b> [98.91]	44 RUTHENIUM <b>Ru</b> 101.07	45 RHODIUM <b>Rh</b> 102.91	46 PALLADIUM <b>Pd</b> 106.4	47 SILVER <b>Ag</b> 107.87	48 CADMIUM <b>Cd</b> 112.40	49 INDIUM <b>In</b> 114.82	50 TIN <b>Sn</b> 118.69	51 ANTIMONY <b>Sb</b> 121.75	52 TELLURIUM <b>Te</b> 127.60	53 IODINE <b>I</b> 126.90	54 XENON <b>Xe</b> 131.30
55 CAESIUM <b>Cs</b> 132.91	56 BARIUM <b>Ba</b> 137.34	57-71	72 HAFNIUM <b>Hf</b> 178.49	73 TANTALUM <b>Ta</b> 180.95	74 TUNGSTEN <b>W</b> 183.85	75 RHENIUM <b>Re</b> 186.2	76 OSMIUM <b>Os</b> 190.2	77 IRIDIUM <b>Ir</b> 192.22	78 PLATINUM <b>Pt</b> 195.09	79 GOLD <b>Au</b> 196.97	80 MERCURY <b>Hg</b> 200.59	81 THALLIUM <b>Tl</b> 204.37	82 LEAD <b>Pb</b> 207.2	83 BISMUTH <b>Bi</b> 208.98	84 POLONIUM <b>Po</b> [210.0]	85 ASTATINE <b>At</b> [210.0]	86 RADON <b>Rn</b> [222.0]
87 FRANCIUM <b>Fr</b> [223.0]	88 RADIUM <b>Ra</b> [226.0]	89-103	104 RUTHERFORDIUM <b>Rf</b> [261]	105 DUBNIUM <b>Db</b> [262]	106 SEABORGIUM <b>Sg</b> [266]	107 BOHRNIUM <b>Bh</b> [262]	108 HASSIUM <b>Hs</b> [265]	109 MEITNERIUM <b>Mt</b> [266]	110 DARMSTADIUM <b>Ds</b> [271]	111 ROENTGENIUM <b>Rg</b> [272]	112 COPERNICIUM <b>Cn</b> [283]	114 FLEROVIUM <b>Fl</b> [289]		116 LIVERMORIUM <b>Lv</b> [293]			

LANTHANOIDS	57 LANTHANUM <b>La</b> 138.91	58 CERIUM <b>Ce</b> 140.12	59 PRASEODYMIUM <b>Pr</b> 140.91	60 NEODYMIUM <b>Nd</b> 144.24	61 PROMETHIUM <b>Pm</b> [144.9]	62 SAMARIUM <b>Sm</b> 150.4	63 EUROPIUM <b>Eu</b> 151.96	64 GADOLINIUM <b>Gd</b> 157.25	65 TERBIUM <b>Tb</b> 158.93	66 DYSPROSIUM <b>Dy</b> 162.50	67 HOLMIUM <b>Ho</b> 164.93	68 ERBIUM <b>Er</b> 167.26	69 THULIUM <b>Tm</b> 168.93	70 YTTERIUM <b>Yb</b> 173.04	71 LUTETIUM <b>Lu</b> 174.97
ACTINOIDS	89 ACTINIUM <b>Ac</b> [227.0]	90 THORIUM <b>Th</b> 232.04	91 PROTACTINIUM <b>Pa</b> [231.0]	92 URANIUM <b>U</b> 238.03	93 NEPTUNIUM <b>Np</b> [237.0]	94 PLUTONIUM <b>Pu</b> [239.1]	95 AMERICIUM <b>Am</b> [243.1]	96 CURIUM <b>Cm</b> [247.1]	97 BERKELIUM <b>Bk</b> [247.1]	98 CALIFORNIUM <b>Cf</b> [252.1]	99 EINSTEINIUM <b>Es</b> [252.1]	100 FERMIUM <b>Fm</b> [257.1]	101 MENDELEVIUM <b>Md</b> [256.1]	102 NOBELIUM <b>No</b> [259.1]	103 LAWRENCIUM <b>Lr</b> [260.1]