

CONFIDENTIAL

NOVEMBER 2008

TIME ALLOWED: THREE HOURS

GIVE THE FOLLOWING INFORMATION IN BLOCK LETTERS

FAMILY NAME		SID NUMBER	
OTHER NAMES		TABLE NUMBER	

OFFICIAL USE ONLY

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 question of the short answer section begins with a •.
- Electronic calculators, including programmable calculators, may be used. Students are warned, however, 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 sheet.
- Page 24 is for rough working only.

Multiple choice section

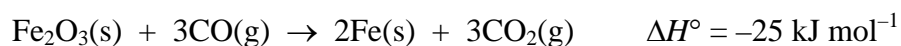
Pages	Marks	
	Max	Gained
2-10	31	

Short answer section

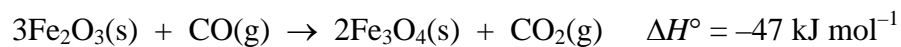
Page	Marks		Marker
	Max	Gained	
11	5		
12	4		
13	5		
14	5		
15	5		
16	6		
17	5		
18	5		
19	5		
20	6		
21	4		
22	6		
23	8		
Total	69		

Marks
5

- Carbon monoxide is commonly used in the reduction of iron ore to iron metal. Iron ore is mostly haematite, Fe_2O_3 , in which case the complete reduction reaction is:



Incomplete reduction, however, results in the formation of magnetite, Fe_3O_4 :



Use these heats of reaction to calculate the enthalpy change when one mole of magnetite is reduced to iron metal using carbon monoxide.

Answer:

Another iron oxide that can be formed as an intermediate during reduction is FeO. Use the following table of thermochemical data to show whether the formation of FeO from Fe_3O_4 is spontaneous or not at 25 °C.

	$\Delta_f H^\circ$ (kJ mol ⁻¹)	S° (J K ⁻¹ mol ⁻¹)
FeO	-272	61
Fe ₃ O ₄	-1118	146
CO	-111	198
CO ₂	-394	214

Marks
4

- A 150.0 g block of iron metal is cooled by placing it in an insulated container with a 50.0 g block of ice at 0.0 °C. The ice melts, and when the system comes to equilibrium the temperature of the water is 78.0 °C. What was the original temperature (in °C) of the iron?

Data: The specific heat capacity of liquid water is $4.184 \text{ J K}^{-1} \text{ g}^{-1}$.

The specific heat capacity of solid iron is $0.450 \text{ J K}^{-1} \text{ g}^{-1}$.

The molar enthalpy of fusion of ice (water) is $6.007 \text{ kJ mol}^{-1}$.

Answer:

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

Marks
5

- The freezing point of a sample of seawater is measured as $-2.15\text{ }^{\circ}\text{C}$ at 1 atm pressure. Assuming that the concentrations of other solutes are negligible, and that the salt does not significantly change the density of the water from 1.00 kg L^{-1} , determine the concentration (in mol L^{-1}) of NaCl in this sample. (The molal freezing point depression constant for H_2O is $1.86\text{ }^{\circ}\text{C m}^{-1}$)

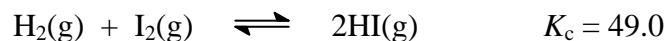
Answer:

In principle, it would be possible to desalinate this water by pumping it into a cylindrical tower, and allowing gravity to push pure water through a semipermeable membrane at the bottom. At $25\text{ }^{\circ}\text{C}$, how high would the tower need to be for this to work? (The density of liquid Hg at $25\text{ }^{\circ}\text{C}$ is 13.53 g cm^{-3} .)

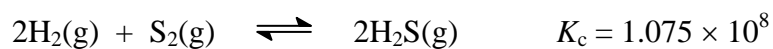
Answer:

Marks
5

- At 700 °C, hydrogen and iodine react according to the following equation.



Hydrogen also reacts with sulfur at 700 °C:



Determine K_c for the following overall equilibrium reaction at 700 °C.



$K_c =$

What is the standard free energy change at 700 °C for this overall equilibrium reaction?

Answer:

THIS QUESTION CONTINUES ON THE NEXT PAGE.

If 0.250 mol of HI(g) is introduced into a 2.00 L flask at 700 °C, what will be the concentration of I₂(g) at equilibrium?

Marks
5

Answer:

If 0.274 g of H₂S were now introduced into the same flask, what would be the concentration of S₂(g) at equilibrium?

Answer:

- Calculate the pH of a 0.10 mol L^{-1} solution of HF. (The pK_a of HF is 3.17.)

Marks
6

Answer:

What mass of NaF needs to be added to 100.0 mL of the above solution to make a buffer with a pH of 3.00?

Answer:

Explain why HCl is a much stronger acid than HF.

Marks
5

- Cisplatin, $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2]$, is a particularly effective chemotherapy agent against certain types of cancer. Calculate the concentration of $\text{Pt}^{2+}(\text{aq})$ ions in solution when 0.075 mol of cisplatin is dissolved in 1.00 L of a 1.00 M solution of NH_3 .
 K_{stab} of $[\text{Pt}(\text{NH}_3)_2\text{Cl}_2] = 3.4 \times 10^{12}$.

Answer:	

What changes would occur to the values of K_{stab} for cisplatin and the concentration of $\text{Pt}^{2+}(\text{aq})$ ions if solid KCl were dissolved in the above solution?

K_{stab}	increase	no change	decrease
$[\text{Pt}^{2+}(\text{aq})]$	increase	no change	decrease

THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

Marks
5

- A galvanic cell is made of a Zn^{2+}/Zn half cell with $[\text{Zn}^{2+}] = 2.0 \text{ M}$ and an Ag^+/Ag half cell with $[\text{Ag}^+] = 0.050 \text{ M}$. Calculate the electromotive force of the cell at 25°C .

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:

Indicate whether the reaction is spontaneous or not. Give a reason for your answer.

Express the overall reaction in the shorthand voltaic cell notation.

Marks
3

- Outline the rules that determine nuclear stability.

2

- Explain why surface effects are important in colloidal systems.

Marks**2**

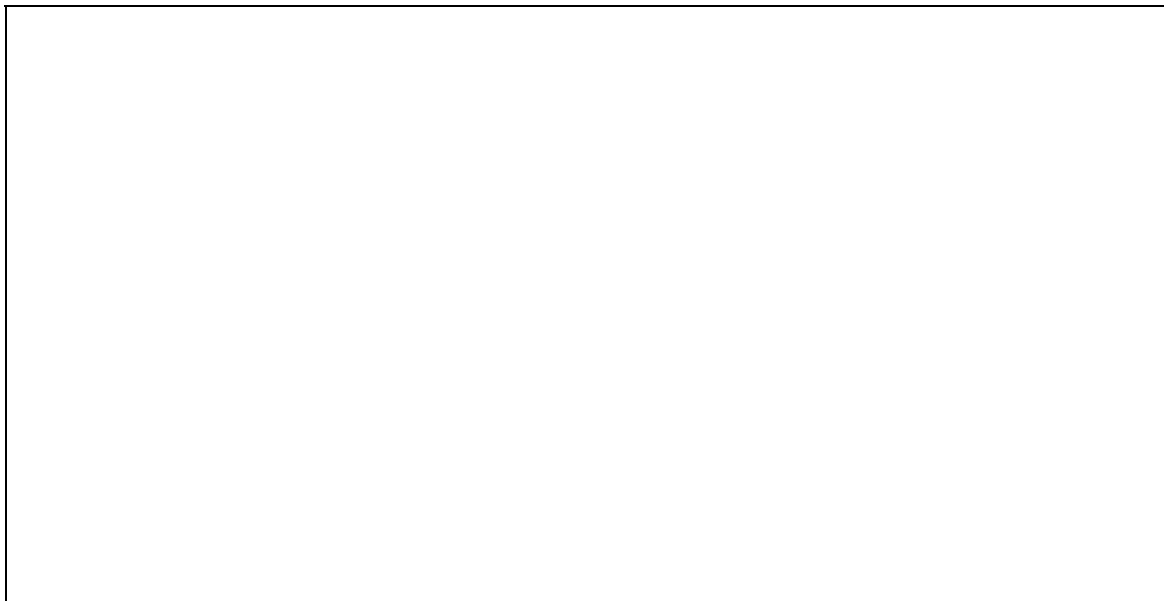
- Explain how soap acts to remove oil.

4

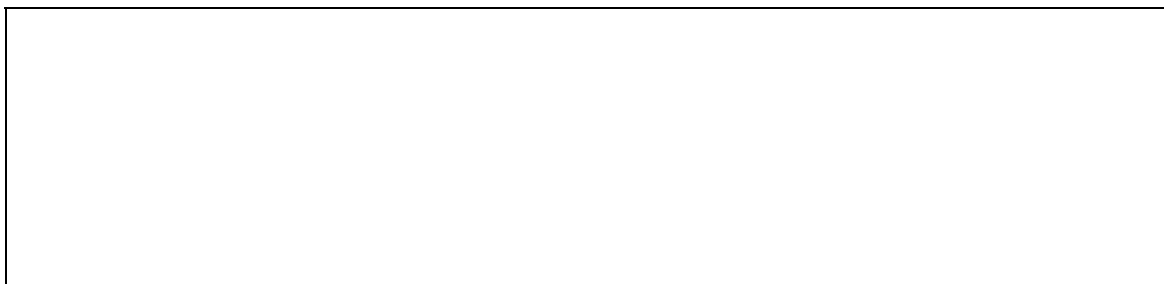
- A melt of NaCl is electrolysed for 35 minutes with a current of 3.50 A. Calculate the mass of sodium and volume of chlorine at 40 °C and 1.00 atm that are formed.

Marks
4

- Draw the potential energy diagram for an endothermic reaction. Indicate on the diagram the activation energy for both the forward and reverse reaction, and the enthalpy of reaction.



Would you expect the forward or the reverse reaction to be faster? Why?



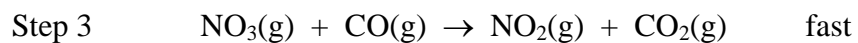
THE REMAINDER OF THIS PAGE IS FOR ROUGH WORKING ONLY

Marks
4

- Consider the reaction: $\text{NO}_2(\text{g}) + \text{CO}(\text{g}) \rightarrow \text{NO}(\text{g}) + \text{CO}_2(\text{g})$

The experimentally determined rate equation is: $\text{Rate} = k[\text{NO}_2(\text{g})]^2$

Show the rate expression is consistent with the following mechanism:



- The rate constant of a particular reaction quadruples when the temperature is increased from 30 °C to 50 °C. Calculate the activation energy, E_a , for this reaction.

2 $E_a =$

Marks
8

- An Ag electrode immersed in a saturated aqueous solution of AgBr has a reduction potential of 0.437 V at 25 °C with respect to the standard hydrogen electrode. Calculate the solubility product of AgBr at 25 °C.

Answer:

A Pd electrode immersed in an aqueous solution containing 0.01 Pd(NO₃)₂ M and 1.00 M NaCl has a reduction potential of -0.860 V at 25 °C with respect to the Ag electrode above. Calculate the stability constant of the complex ion, [PdCl₄]²⁻, at 25 °C.

Answer:

CHEM1109 - CHEMISTRY 1B LIFE SCIENCES**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 × 10¹⁰ 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
10 ¹²	tera	T

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Reaction	E° / V
$\text{S}_2\text{O}_8^{2-} + 2\text{e}^- \rightarrow 2\text{SO}_4^{2-}$	+2.01
$\text{Co}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Co}^{2+}(\text{aq})$	+1.82
$\text{Ce}^{4+}(\text{aq}) + \text{e}^- \rightarrow \text{Ce}^{3+}(\text{aq})$	+1.72
$\text{Au}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Au}(\text{s})$	+1.50
$\text{Cl}_2 + 2\text{e}^- \rightarrow 2\text{Cl}^-(\text{aq})$	+1.36
$\text{O}_2 + 4\text{H}^+(\text{aq}) + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$	+1.23
$\text{Br}_2 + 2\text{e}^- \rightarrow 2\text{Br}^-(\text{aq})$	+1.10
$\text{MnO}_2(\text{s}) + 4\text{H}^+(\text{aq}) + \text{e}^- \rightarrow \text{Mn}^{3+} + 2\text{H}_2\text{O}$	+0.96
$\text{Pd}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Pd}(\text{s})$	+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
$\text{Co}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Co}(\text{s})$	-0.28
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$	-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
$\text{Mg}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Mg}(\text{s})$	-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

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Useful formulas

<p>Thermodynamics & Equilibrium</p> $\Delta U = q + w = q - p\Delta V$ $\Delta_{\text{universe}}S = \Delta_{\text{sys}}S - \frac{\Delta_{\text{sys}}H}{T_{\text{sys}}}$ $\Delta G^{\circ} = \Delta H^{\circ} - T\Delta S^{\circ}$ $\Delta G = \Delta G^{\circ} + RT \ln Q$ $\Delta G^{\circ} = -RT \ln K$ $K_p = K_c (RT)^{\Delta n}$	<p>Electrochemistry</p> $\Delta G^{\circ} = -nFE^{\circ}$ <p>Moles of $e^{-} = It/F$</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>Colligative properties</p> $\pi = cRT$ $P_{\text{solution}} = X_{\text{solvent}} \times P^{\circ}_{\text{solvent}}$ $p = kc$ $\Delta T_f = K_f m$ $\Delta T_b = K_b m$	<p>Quantum Chemistry</p> $E = h\nu = hc/\lambda$ $\lambda = h/mv$ $4.5k_B T = hc/\lambda$ $E = -Z^2 E_R (1/n^2)$ $\Delta x \cdot \Delta(mv) \geq h/4\pi$ $q = 4\pi r^2 \times 5.67 \times 10^{-8} \times T^4$
<p>Acids and Bases</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>Gas Laws</p> $PV = nRT$ $(P + n^2a/V^2)(V - nb) = nRT$
<p>Radioactivity</p> $t_{1/2} = \ln 2 / \lambda$ $A = \lambda N$ $\ln(N_0/N_t) = \lambda t$ $^{14}\text{C age} = 8033 \ln(A_0/A_t)$	<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>Miscellaneous</p> $A = -\log_{10} \frac{I}{I_0}$ $A = \epsilon cl$ $E = -A \frac{e^2}{4\pi\epsilon_0 r} N_A$	<p>Mathematics</p> <p>If $ax^2 + bx + c = 0$, then $x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$</p> $\ln x = 2.303 \log x$

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]							

LANTHANOIDS	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 YTTERIUM 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]	103 LAWRENCIUM Lr [260.1]