### Standard states of the elements

# The most stable form of an element at 298 K and 1 atm ("STP")

#### Metals

All solids except one (which one?)

Metalloids
All solids

#### **Nonmetals**

Atomic gases – Noble gases He, Ne, Ar, Kr, Xe, Rn

<u>Diatomics</u> – halogens and H<sub>2</sub>, N<sub>2</sub>, O<sub>2</sub> H<sub>2</sub>, N<sub>2</sub>, O<sub>2</sub> (gas)

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F<sub>2</sub> (gas)
Cl<sub>2</sub> (gas)
Br<sub>2</sub> (liquid)
l<sub>2</sub> (solid)
Halogens (group 7)
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Other nonmetals – solids C (graphite), S, P, Se

## PERIODIC TABLE of the ELEMENTS Standard States

MAIN GI	ROUPS											MAIN GROUPS					
1A																	8A
1																	18
1																	2
Н	2A											3A	4A	5A	6A	7A	He
1.008	2											13	14	15	16	17	4.003
3	4											5	6	7	8	9	10
Li	Be		TRANSITION METALS									B	Č	N	Ö	Ě	Ne
6.941	9.012											10.811	12.011	14.007	15.999	18.998	20.180
11	12											13	14	15	16	17	18
Na	Mg	3B	4B	5B	6B	7B	8B	8B	8B	1B	2B	Al	Si	Р	S	CI	Ar
22.990	24.305	3	4	5	6	7	8	9	10	11	12	26.982	28.086	30.974	32.066	35.453	39.948
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	_	_		l	_		_	_		_	_	_		_	_	_	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
39.098	40.078	44.956	47.867	50.942	51.996	54.938	55.845	58.933	58.693	63.546	65.39	69.723	72.61	74.992	78.96	79.904	83.80
39.098	40.078	44.956 <b>39</b>	47.867 <b>40</b>	50.942 <b>41</b>	51.996 <b>42</b>	54.938 <b>43</b>	55.845 <b>44</b>	58.933 <b>45</b>	58.693 <b>46</b>		65.39 <b>48</b>	69.723 <b>49</b>	72.61 <b>50</b>	74.992 <b>51</b>	78.96 <b>52</b>		83.80 <b>54</b>
39.098	40.078 38 <b>Sr</b>	44.956 <b>39</b> <b>Y</b>	47.867 40 <b>Zr</b>	50.942 41 <b>Nb</b>	51.996 42 <b>Mo</b>	54.938	55.845 44 <b>Ru</b>	58.933 45 <b>Rh</b>	58.693 46 <b>Pd</b>	63.546 47 <b>Ag</b>	65.39 48 <b>Cd</b>	69.723 49 <b>In</b>	72.61 50 <b>Sn</b>	74.992 51 <b>Sb</b>	<sup>78.96</sup> <b>52 Te</b>	79.904 53 <b>I</b>	83.80 54 <b>Xe</b>
39.098 37 <b>Rb</b> 85.468	40.078 38 <b>Sr</b> 87.62	39 <b>Y</b> 88.906	47.867 40 <b>Zr</b> 91.224	50.942 41 <b>Nb</b> 92.906	51.996 42 <b>Mo</b> 95.94	54.938 43 <b>Tc</b> [98]	55.845 44 <b>Ru</b> 101.07	58.933 <b>45</b> <b>Rh</b> 102.90	58.693 46 <b>Pd</b> 106.42	63.546 47 <b>Ag</b> 107.87	65.39 48 <b>Cd</b> 112.41	69.723 49 <b>In</b> 114.82	72.61 50 <b>Sn</b> 118.71	74.992 51 <b>Sb</b> 121.76	78.96 <b>52</b> <b>Te</b> 127.60	79.904 53   126.90	83.80 54 <b>Xe</b> 131.29
39.098 37 <b>Rb</b> 85.468 55	40.078 38 <b>Sr</b> 87.62 56	39 Y 88.906	47.867 40 <b>Zr</b> 91.224 72	50.942 41 <b>Nb</b> 92.906 73	51.996 42 <b>Mo</b> 95.94 74	54.938 43 <b>Tc</b> [98] 75	55.845 44 <b>Ru</b> 101.07 76	58.933 45 <b>Rh</b> 102.90	58.693 46 <b>Pd</b> 106.42 78	63.546 47 <b>Ag</b> 107.87	65.39 48 <b>Cd</b> 112.41 80	69.723 49 <b>In</b> 114.82 81	72.61 50 <b>Sn</b> 118.71 82	74.992 51 <b>Sb</b> 121.76	78.96 <b>52</b> <b>Te</b> 127.60	79.904 53 <b>I</b> 126.90 85	83.80 54 <b>Xe</b> 131.29 86
39.098 37 <b>Rb</b> 85.468 55 <b>Cs</b>	40.078 38 <b>Sr</b> 87.62 56 <b>Ba</b>	44.956 39 Y 88.906 57 <b>La*</b>	47.867 40 <b>Zr</b> 91.224 72 <b>Hf</b>	50.942 41 <b>Nb</b> 92.906 73 <b>Ta</b>	51.996 42 <b>Mo</b> 95.94 74 <b>W</b>	54.938 43 <b>Tc</b> [98] 75 <b>Re</b>	55.845 44 <b>Ru</b> 101.07 76 <b>Os</b>	58.933 45 <b>Rh</b> 102.90 77 <b>Ir</b>	58.693 46 Pd 106.42 78 Pt	63.546 47 <b>Ag</b> 107.87 79 <b>Au</b>	65.39 48 Cd 112.41 80 Hg	69.723 49 In 114.82 81 TI	72.61 50 <b>Sn</b> 118.71 82 <b>Pb</b>	74.992 51 <b>Sb</b> 121.76 83 <b>Bi</b>	78.96 52 <b>Te</b> 127.60 84 <b>Po</b>	79.904 53 I 126.90 85 At	83.80 54 <b>Xe</b> 131.29 86 <b>Rn</b>
39.098 37 <b>Rb</b> 85.468 55 <b>Cs</b> 132.91	40.078 38 <b>Sr</b> 87.62 56 <b>Ba</b> 137.33	44.956 39 Y 88.906 57 <b>La*</b> 138.91	47.867 40 <b>Zr</b> 91.224 <b>72</b> <b>Hf</b> 178.49	50.942 41 <b>Nb</b> 92.906 <b>73</b> <b>Ta</b> 180.95	51.996 42 <b>Mo</b> 95.94 <b>74</b> <b>W</b> 183.84	54.938 43 <b>Tc</b> [98] <b>75</b> <b>Re</b> 186.21	55.845 44 <b>Ru</b> 101.07 <b>76</b> <b>Os</b> 190.23	58.933 45 <b>Rh</b> 102.90 <b>77</b> <b>Ir</b> 192.22	58.693 46 <b>Pd</b> 106.42 78 <b>Pt</b> 195.08	63.546 47 <b>Ag</b> 107.87 <b>79</b> <b>Au</b> 196.97	65.39 48 Cd 112.41 80 Hg 200.59	69.723 49 <b>In</b> 114.82 81	72.61 50 <b>Sn</b> 118.71 82 <b>Pb</b> 207.2	74.992 51 <b>Sb</b> 121.76	78.96 52 <b>Te</b> 127.60 84 <b>Po</b> [209]	79.904 53 <b>I</b> 126.90 85	83.80 54 <b>Xe</b> 131.29 86 <b>Rn</b> [222]
39.098 37 <b>Rb</b> 85.468 55 <b>Cs</b> 132.91 87	40.078 38 Sr 87.62 56 Ba 137.33 88	44.956 39 Y 88.906 57 <b>La*</b> 138.91 89	47.867 40 <b>Zr</b> 91.224 72 <b>Hf</b> 178.49	50.942 41 <b>Nb</b> 92.906 73 <b>Ta</b> 180.95	51.996 42 <b>Mo</b> 95.94 74 <b>W</b> 183.84	54.938 43 Tc [98] 75 Re 186.21 107	55.845 44 <b>Ru</b> 101.07 76 <b>Os</b> 190.23	58.933 45 <b>Rh</b> 102.90 77 <b>Ir</b> 192.22 109	58.693 46 Pd 106.42 78 Pt	63.546 47 <b>Ag</b> 107.87 79 <b>Au</b>	65.39 48 Cd 112.41 80 Hg	69.723 49 In 114.82 81 TI	72.61 50 <b>Sn</b> 118.71 82 <b>Pb</b>	74.992 51 <b>Sb</b> 121.76 83 <b>Bi</b>	78.96 52 <b>Te</b> 127.60 84 <b>Po</b>	79.904 53 I 126.90 85 At	83.80 54 <b>Xe</b> 131.29 86 <b>Rn</b>
39.098 37 <b>Rb</b> 85.468 55 <b>Cs</b> 132.91 87 <b>Fr</b>	40.078 38 Sr 87.62 56 Ba 137.33 88 Ra	44.956 39 Y 88.906 57 <b>La*</b> 138.91 89 <b>Ac**</b>	47.867 40 <b>Zr</b> 91.224 72 <b>Hf</b> 178.49 104 <b>Rf</b>	50.942 41 <b>Nb</b> 92.906 73 <b>Ta</b> 180.95 105 <b>Db</b>	51.996 42 <b>Mo</b> 95.94 74 <b>W</b> 183.84 106 <b>Sg</b>	54.938 43 Tc [98] 75 Re 186.21 107 Bh	55.845 44 Ru 101.07 76 Os 190.23 108 Hs	58.933 45 <b>Rh</b> 102.90 77 <b>Ir</b> 192.22 109 <b>Mt</b>	58.693 46 Pd 106.42 78 Pt 195.08	63.546 47 <b>Ag</b> 107.87 79 <b>Au</b> 196.97	65.39 48 Cd 112.41 80 Hg 200.59	69.723 49 In 114.82 81 TI	72.61 50 Sn 118.71 82 Pb 207.2 114	74.992 51 <b>Sb</b> 121.76 83 <b>Bi</b>	78.96 52 <b>Te</b> 127.60 84 <b>Po</b> [209] 116	79.904 53 I 126.90 85 At	83.80 54 <b>Xe</b> 131.29 86 <b>Rn</b> [222] 118
39.098 37 <b>Rb</b> 85.468 55 <b>Cs</b> 132.91 87	40.078 38 Sr 87.62 56 Ba 137.33 88	44.956 39 Y 88.906 57 <b>La*</b> 138.91 89	47.867 40 <b>Zr</b> 91.224 72 <b>Hf</b> 178.49	50.942 41 <b>Nb</b> 92.906 73 <b>Ta</b> 180.95	51.996 42 <b>Mo</b> 95.94 74 <b>W</b> 183.84	54.938 43 Tc [98] 75 Re 186.21 107	55.845 44 <b>Ru</b> 101.07 76 <b>Os</b> 190.23	58.933 45 <b>Rh</b> 102.90 77 <b>Ir</b> 192.22 109	58.693 46 <b>Pd</b> 106.42 78 <b>Pt</b> 195.08	63.546 47 <b>Ag</b> 107.87 <b>79</b> <b>Au</b> 196.97	65.39 48 Cd 112.41 80 Hg 200.59	69.723 49 In 114.82 81 TI	72.61 50 <b>Sn</b> 118.71 82 <b>Pb</b> 207.2	74.992 51 <b>Sb</b> 121.76 83 <b>Bi</b>	78.96 52 <b>Te</b> 127.60 84 <b>Po</b> [209]	79.904 53 I 126.90 85 At	83.80 54 <b>Xe</b> 131.29 86 <b>Rn</b> [222]
39.098 37 <b>Rb</b> 85.468 55 <b>Cs</b> 132.91 87 <b>Fr</b>	40.078 38 Sr 87.62 56 Ba 137.33 88 Ra	44.956 39 Y 88.906 57 <b>La*</b> 138.91 89 <b>Ac**</b>	47.867 40 <b>Zr</b> 91.224 72 <b>Hf</b> 178.49 104 <b>Rf</b>	50.942 41 <b>Nb</b> 92.906 <b>73</b> <b>Ta</b> 180.95 <b>105</b> <b>Db</b> [262]	51.996 42 Mo 95.94 74 W 183.84 106 Sg [266]	54.938 43 Tc [98] 75 Re 186.21 107 Bh [264]	55.845 44 Ru 101.07 76 Os 190.23 108 Hs [265]	58.933 45 <b>Rh</b> 102.90 77 <b>Ir</b> 192.22 109 <b>Mt</b> [268]	58.693 46 Pd 106.42 78 Pt 195.08 110	63.546 47 <b>Ag</b> 107.87 79 <b>Au</b> 196.97 111	65.39 48 Cd 112.41 80 Hg 200.59 112	69.723 49 In 114.82 81 TI 204.38	72.61 50 Sn 118.71 82 Pb 207.2 114 [285]	74.992 51 <b>Sb</b> 121.76 83 <b>Bi</b> 208.98	78.96 52 <b>Te</b> 127.60 84 <b>Po</b> [209] 116	79.904 53 I 126.90 85 At [210]	83.80 54 <b>Xe</b> 131.29 86 <b>Rn</b> [222] 118
39.098 37 <b>Rb</b> 85.468 55 <b>Cs</b> 132.91 87 <b>Fr</b>	40.078 38 Sr 87.62 56 Ba 137.33 88 Ra [226]	44.956 39 Y 88.906 57 <b>La*</b> 138.91 89 <b>Ac**</b>	47.867 40 <b>Zr</b> 91.224 72 <b>Hf</b> 178.49 104 <b>Rf</b> [261]	50.942 41 <b>Nb</b> 92.906 73 <b>Ta</b> 180.95 105 <b>Db</b>	51.996 42 <b>Mo</b> 95.94 74 <b>W</b> 183.84 106 <b>Sg</b>	54.938 43 Tc [98] 75 Re 186.21 107 Bh	55.845 44 Ru 101.07 76 Os 190.23 108 Hs	58.933 45 <b>Rh</b> 102.90 77 <b>Ir</b> 192.22 109 <b>Mt</b>	58.693 46 Pd 106.42 78 Pt 195.08	63.546 47 <b>Ag</b> 107.87 79 <b>Au</b> 196.97	65.39 48 Cd 112.41 80 Hg 200.59	69.723 49 In 114.82 81 TI	72.61 50 Sn 118.71 82 Pb 207.2 114	74.992 51 <b>Sb</b> 121.76 83 <b>Bi</b>	78.96 52 <b>Te</b> 127.60 84 <b>Po</b> [209] 116	79.904 53 I 126.90 85 At	83.80 54 <b>Xe</b> 131.29 86 <b>Rn</b> [222] 118

\*\* ACTINOIDS

58	59	60	61	62	63	64	65	66	67	68	69	70	71
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Но	Er	Tm	Yb	Lu
140.12	140.91	144.24	[145]	150.36	151.96	157.25	158.92	162.50	164.93	167.26	168.93	173.04	174.97
90	91	92	93	94	95	96	97	98	99	100	101	102	103
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
232.04	231.04	238.03	[237]	[244]	[243]	[247]	[247]	[251]	[252]	[257]	[258]	[259]	[262]