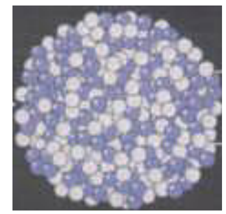
- How are the elements formed?
- What fuels the stars?
- Can PET be used to tell if my brain works?
- How can a doctor watch my heat beat with PET?
- How can a solar flare disable my cell phone?
- How can a dirty bomb be detected?
- Can radiation really cure cancer?
- How can we monitor our boarders for importation of nuclear material?
- Where does indoor radon come from?
- What are the limits of nuclear stability?
- How can scientists tell the age of artifacts?
- Is there really a non-destructive method to determine elemental composition?

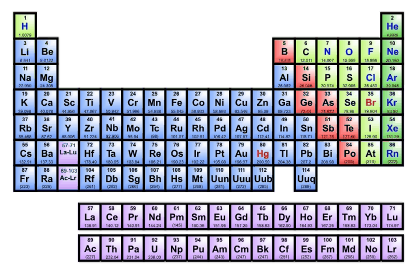
The answers to these and many other questions are rooted in the science of the nucleus.

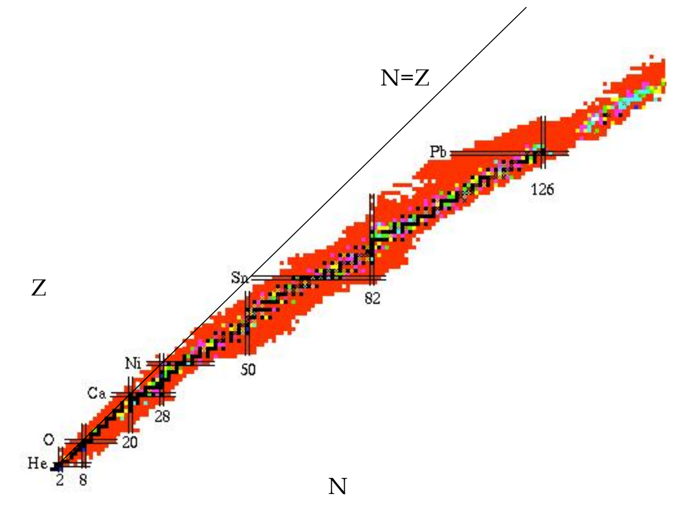


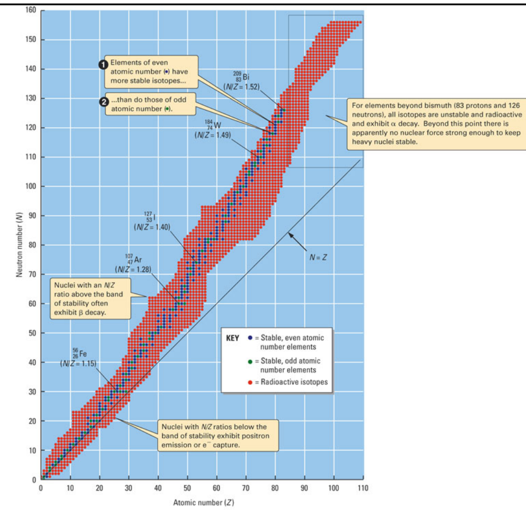
Periodic Table of The Elements

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
1 H 1.008																1 H 1.008	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.88	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.61	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.2	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.2	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Ha (262)	106 Sg (263)	107 Ns (262)	108 Hs	109 Mt									

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.97	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)

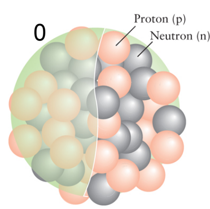






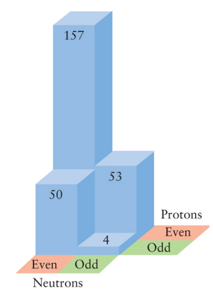
the players

particle	mass	charge	spin
leptons			
electrons	511KeV	-1	1/2
positrons	511KeV	+1	1/2
gamma rays	0	0	1
neutrinos	0	0	1/2
nucleons			
neutrons	1.00866amu	0	1/2
protons	1.00728amu	+1	1/2
nuclei			
alpha particles	4.0026amu	+2	0
fission fragments			



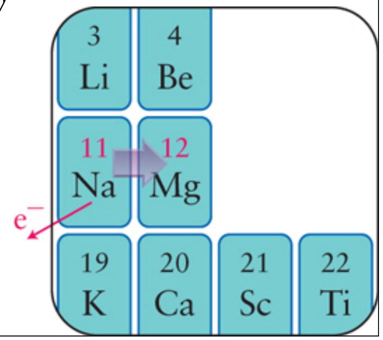
Nuclear stability

- valley of stability - stable isotopes
- Even-Even : most stable
- Odd-Even (or Even-Odd) : somewhat stable
- Odd-Odd : 4 known stable



Beta Decay

- β^- decay (n–>p)
- $^{16}N \rightarrow {}^{16}O + \beta^- + \bar{\nu}$



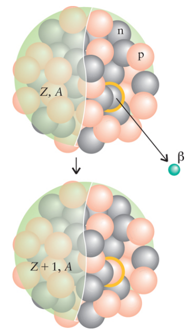
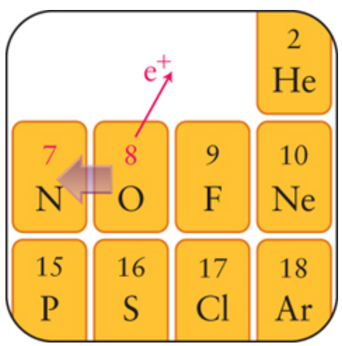


FIGURE 17.8 When a nucleus ejects a β particle, the atomic number of the nuclide increases by 1 and the mass number remains unchanged. The neutron that we can regard as the source of the electron is indicated by the gold boundary in the upper nucleus.

Beta Decay

- positron decay (p–>n)
- $^{18}F \rightarrow {}^{18}O + \beta^+ + \nu$



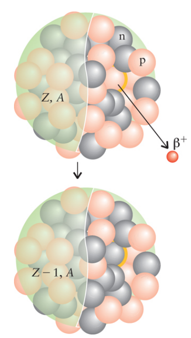
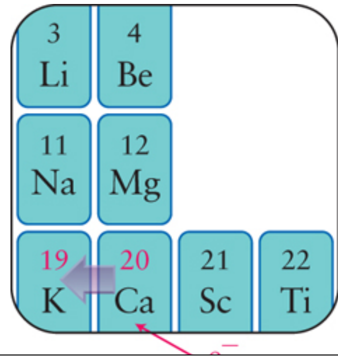


FIGURE 17.10 In positron (β^+) emission, the nucleus ejects a positron. The effect is to convert a proton into a neutron. As a result, the atomic number of the nuclide decreases by 1 but the mass number remains the same.

Beta Decay

- electron capture (p–>n)
- $^{15}O + e^{-} \rightarrow {}^{15}N + \nu$



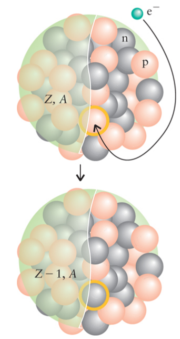
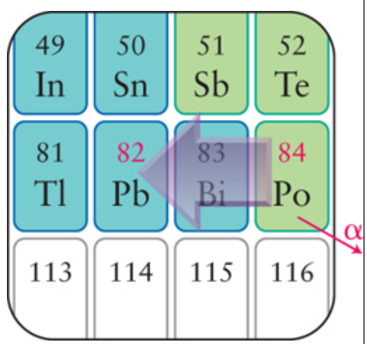


FIGURE 17.9 In electron capture, a nucleus captures one of the surrounding electrons. The effect is to convert a proton (outlined in gold) into a neutron (outlined in gold). As a result, the atomic number of the nuclide decreases by 1 but the mass number remains the same.

alpha decay

- $^{220}Rn \rightarrow {}^{216}Po + {}^{4}He$
- heavy nuclei

$${}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}X + {}^{4}_{2}He$$



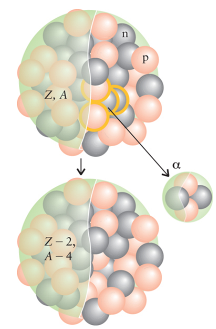
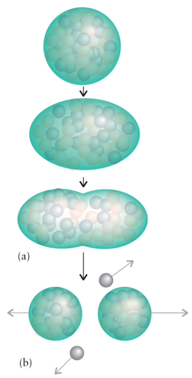


FIGURE 17.7 When a nucleus ejects an α particle, the atomic number of the nuclide decreases by 2 and the mass number decreases by 4. The nucleons ejected from the upper nucleus are indicated by the gold boundary.

spontaneous fission

- $^{254}Cf \rightarrow {}^{110}Mo + {}^{144}Ba$
- only heavy nuclei



Energetics

- $E=mc^2$
- how bound is ^{14}C?
- BE = sum masses - mass
- 1 atomic mass unit = 1.66×10^{-27}Kg = 931.5 MeV

BE= 6(mass hydrogen)+8(mass neutron) - mass ^{14}C

=6(1.00783)+8(1.00866)-14.0032419 amu

=.112989 amu

=0.112989 amu (931.5 MeV/amu) = 105.2 MeV

=7.5 Mev/nucleon

($=1.69 \times 10^{-4}$ J {Kgm^2/s^2})