Chapter 10: Debris and the Formation of the Solar System

Radioactive elements decay with a characteristic _____ , the time it takes for half of a sample to decay.

alpha decay produces an alpha particle (essentially a _____)
beta decay involves _____
β^- decay is the conversion of a _____ into a _____
β^+ decay involves positron emission or electron _____

To age date a meteorite, you would preferably use a radioactive isotope that has a very long half-life, e.g.,

^{40}K decays into ^{40}Ar with a half-life of 1.3 Gyr
^{238}U decays into ^{206}Pb with a half-life of 4.5 Gyr
^{87}Rb decays into ^{87}Sr with a half-life of 49.7 Gyr

Periodic Table of Elements

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1																	2
2	3	4										5	6	7	8	9	10
3	11	12										13	14	15	16	17	18
4	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
5	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
6	55	56	57–71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
7	87	88	89–103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118

Atomic #
Symbol
Name
Atomic Mass

C Solid
Hg Liquid
H Gas
Rf Unknown

Metals: Alkali metals; Alkaline earth metals; Lanthanoids; Actinoids; Transition metals; Poor metals

Nonmetals: Other nonmetals; Noble gases

	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
	La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
	Lanthanum	Cerium	Praseodymium	Neodymium	Promethium	Samarium	Europium	Gadolinium	Terbium	Dysprosium	Holmium	Erbium	Thulium	Ytterbium	Lutetium
	138.90547	140.116	140.90765	144.242	(145)	150.36	151.964	157.25	158.92535	162.500	164.93032	167.259	168.93421	173.054	174.9668
	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
	Actinium	Thorium	Protactinium	Uranium	Neptunium	Plutonium	Americium	Curium	Berkelium	Californium	Einsteinium	Fermium	Mendelevium	Nobelium	Lawrencium
	(227)	232.03806	231.03588	238.02891	(237)	(244)	(243)	(247)	(247)	(251)	(252)	(257)	(258)	(259)	(262)

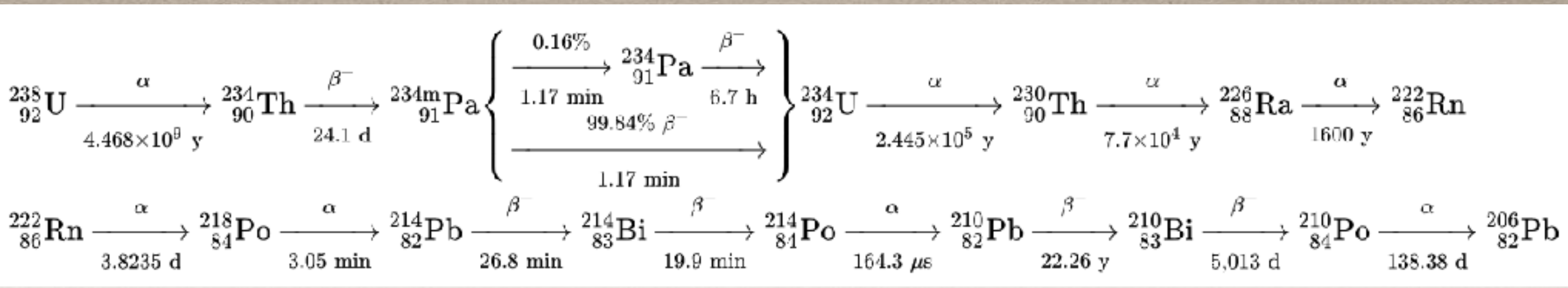
For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.

Ptable.com

We typically encounter the ^{39}K and ^{40}Ar isotopes for potassium and argon, or 19p+20n and 18p+22n, respectively.
How many protons and neutrons are in ^{40}K?
What is necessary for ^{40}K to decay into ^{40}Ar?

We typically encounter the ^{85}Rb and ^{88}Sr isotopes for rubidium and strontium, or 37p+48n and 38p+50n, respectively.
How many protons and neutrons are in ^{87}Rb?
How many protons and neutrons are in ^{87}Sr?
What is necessary for ^{87}Rb to decay into ^{87}Sr?

The chain of events is a bit more complicated for ^{238}U to decay into ^{206}Pb:



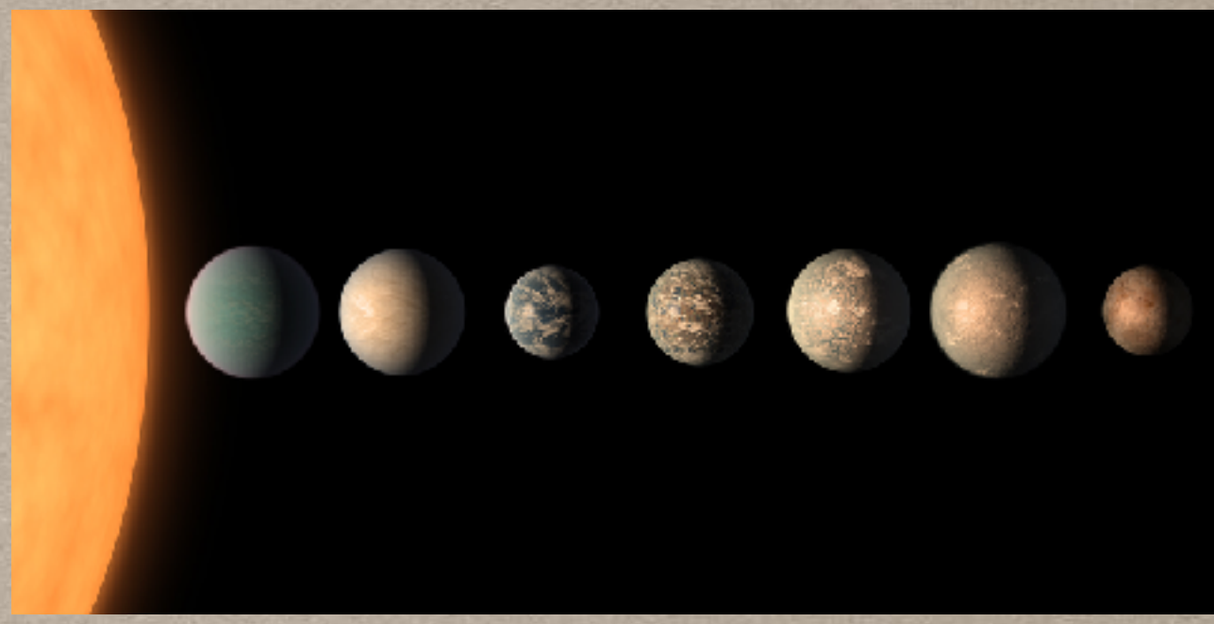
learning checkpoint: what kind of radioactive decay process is involved during the first step, when ^{238}U decays to ^{234}Th?

The equation for the number of particles as a function of time is

$$n(t) = n(t=0)\ 2^{-t/t\_half}$$

or

$$t = t\_half\ 3.322\ \log_{10}[n(t=0)/n(t)].$$



Q: Suppose that in the Trappist-1 planetary system you encounter an alien race that stupidly has decided to use third-lives instead of half-lives for expressing radioactive decay rates. What would be the equivalent mathematical expressions?

n(t) =

t =

Review Examples 1 & 2 on Pages 3 & 4

Q: Suppose we have rock that initially had no ^{40}Ar but now has 40% as much ^{40}Ar as ^{40}K. How old is the rock?

You gotta love small-town local news: meteorite hits Wethersfield home in 1982.

In-class group work on radioactivity (see Chapter 10 Tutorials link)