Radioactive Decay Worksheet

Alpha decay: nucleus spontaneously emits an alpha particle (symbol: α particle), which is 2 p+ and 2 n (or also the same as a Helium (He) atom).

Result: atomic number decreases by 2 (lost 2 p+)
Result: atomic mass decreases by 4 (lost 2 p+ and 2n = 4 amu)

Beta decay: neutron in nucleus spontaneously emits a beta particle (symbol: β particle), which is essentially an electron trapped in a neutron. The neutron, therefore, turns itself into a proton.

Result: atomic number increases by 1 (gained 1 p+)
Result: atomic mass stays same (no mass lost or gained: β particle or electrons have no mass)

Beta or electron capture: proton in nucleus captures a beta particle (symbol: β particle), which is essentially an electron that can become part of a neutron. The proton, therefore, turns itself into a neutron.

Result: atomic number decreases by 1 (lost 1 p+)
Result: atomic mass stays same (no mass lost or gained: β particle or electrons have no mass)

Example

Original	**alpha decay**	**beta decay**	**alpha decay**	**beta capture**	**beta decay**	**alpha decay**
85	83	84	82	81	82	80
At	Bi	Po	Pb	Tl	Pb	Hg
Astatine	Bismuth	Polonium	Lead	Thallium	Lead	Mercury
210	206	206	202	202	202	198

Complete this table

Original	**beta decay**	**alpha decay**	**beta capture**	**alpha decay**	**alpha decay**	**beta decay**
90						
Th						
Thorium						
232						

Complete this table

Original	**beta capture**	**alpha decay**	**alpha decay**	**beta capture**	**alpha decay**	**beta decay**
92						
U						
Uranium						
238						

Radiometric Dating Worksheet

When radioactive isotopes (parent – P) decay, they produce daughter products (D) at a constant rate, called the half-life (**T**). Example: if we start with 100 atoms of the parent, after one half-life, there will be 50 parent atoms remaining and 50 daughter atoms newly made. After another half-life (two half-lives), there will be 25 parent atoms remaining and now 75 daughter atoms. Each parent-daughter isotope pair has its own half-life. To achieve the above example with U-238 takes 9 billion years (two half-lives). To achieve the above example with C-14 takes 11400 years (two half-lives). In the geologic environment, we use a mass spectrometer to count the number of Parent and Daughter atoms in a closed-system (like minerals crystallizing from magmas), and use the relative proportions to find out how old the closed-system is.

1. Assuming we start with only parent isotopes (no daughter), after one half-life has passed, there should be ½ parent remaining and ½ daughter newly formed. The ratio of P:D is ½ : ½ or 1:1. Complete the rest of this table, as in the first example:

# Halflives	Fraction of original Parent remaining	Fraction of original parent turned into daughter	Parent:Daughter ratio
1	½	½	1:1
2			
3			
4			
5			
6			

Not all rocks can be dated radiometrically. Some because they cannot maintain closed systems (like metamorphic rocks); others because they do not contain radioactive isotopes (like quartz sandstones); and finally some because the radioactive isotopes that they do contain have half-lives that are either too long or too short to be measured for a rock of a certain age (like trying to date a 1 m.y.-old rock by using C-14 decay – which would have been completely decayed after about 150,000 years).

Parent (P)	Daughter (D)	Half-lives ($T_{1/2}$)	Materials dated
U-238	Pb-206	4.5×10^9 yr	Zircon (igneous rocks – source; and sedimentary rocks as grains)
U-235	Pb-207	0.7×10^9 yr	Zircon (igneous rocks – source; and sedimentary rocks as grains)
K-40	Ar-40	1.4×10^9 yr	Micas, volcanic rock (igneous rocks)
C-14	N-14	5700 yr	Shells, limestone, organic materials

2. To date the age of a shell found in an old Indian fishing village, which isotope pair would you measure? Why?

3. If you want to date a meteorite, which isotope pair would you measure? Why?

4. If you want to date lava flows on an old lava flow on Kauai (probably about 8 m.y.), which isotope pair would you measure? Why?

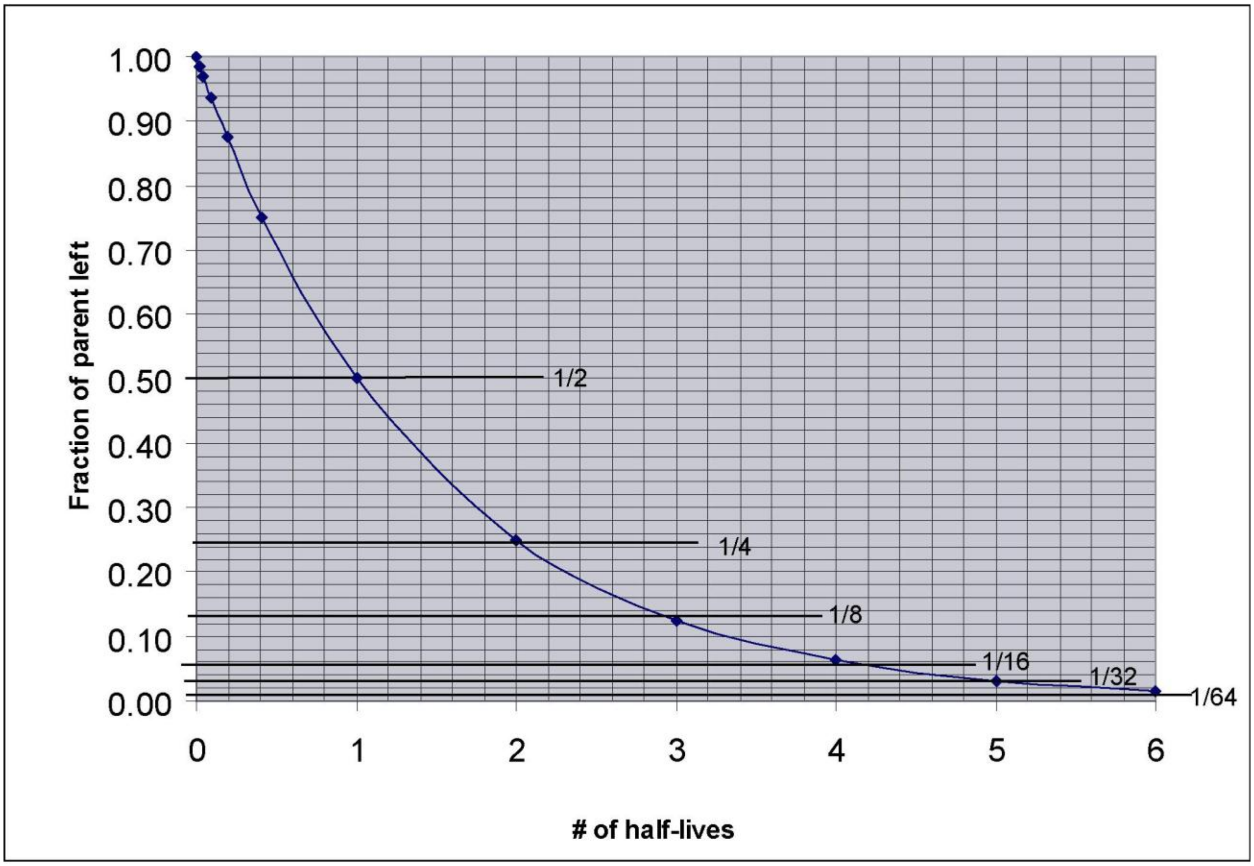
5. If you want to date zircon crystals in ancient sandstones in Australia, which isotope pair would you measure? Why?

6. If the C-14:N-14 ratio in a shell in a sandstone was found to be 1:3, how old is the shell?

7. If the U-235:Pb-207 ratio in a zircon in a sandstone was found to be 1:3, how old is the zircon?

8. If the K-40:Ar-40 ratio in a zircon in a granite was found to be 1:1, how old is the sample?

9. If the U-238:Pb-206 ratio in a zircon in a lava flow was found to be 3:1, how old is the flow?



T (# of) Halflives	Fraction Parent	Daughter	Ratio
0	1	0	infinity :1
0.0227	63/64	1/64	63 :1
0.0458	31/32	1/32	31 :1
0.0931	15/16	1/16	15 :1
0.1927	7/8	1/8	7 :1
0.4151	3/4	1/4	3 :1
1.0000	1/2	1/2	1:1
2.0000	1/4	3/4	1:3
3.0000	1/8	7/8	1:7
4.0000	1/16	15/16	1:15
5.0000	1/32	31/32	1:31
6.0000	1/64	63/64	1:63

CURVE EQUATION: $T = -1.443\ln(f)$ f = fraction of parent left; T = # of half lives that have passed