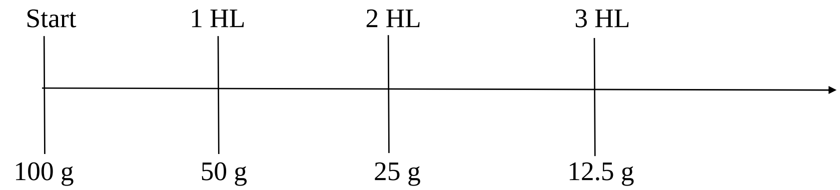
Regents Nuclear Review **ANSWERS**

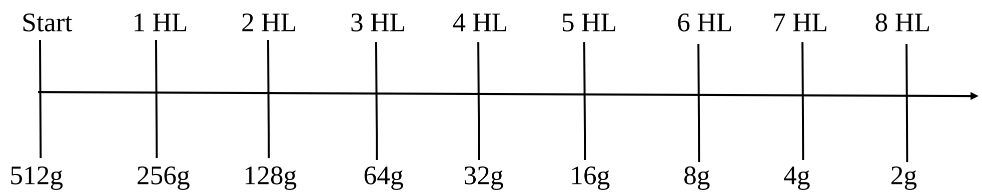
Nuclide	Name of Radiation emitted	Complete Decay Reaction
Fe-53	Positron $^{0}_{+1}e$	$^{53}_{26}Fe \longrightarrow ^{0}_{+1}e + ^{53}_{27}Co$
H-3	Beta $^{0}_{-1}e$	$^{3}_{1}H \longrightarrow ^{0}_{-1}e + ^{3}_{2}He$
Th-232	Alpha $^{4}_{2}He$	$^{232}_{90}U \longrightarrow ^{4}_{2}He + ^{228}_{88}Ra$
U-238	Alpha $^{4}_{2}He$	$^{238}_{92}U \longrightarrow ^{4}_{2}He + ^{234}_{90}Th$
Cs-137	Beta $^{0}_{-1}e$	$^{137}_{55}Cs \longrightarrow ^{0}_{-1}e + ^{137}_{56}Ba$
P-32	Beta $^{0}_{-1}e$	$^{32}_{16}P \longrightarrow ^{0}_{-1}e + ^{32}_{19}K$
K-37	Positron $^{0}_{+1}e$	$^{37}_{19}K \longrightarrow ^{0}_{+1}e + ^{37}_{18}Ar$
Fr-220	Alpha $^{4}_{2}He$	$^{220}_{87}Fr \longrightarrow ^{4}_{2}He + ^{216}_{85}At$

2. If you start with 100.0 grams of K-42, how long until you have just 12.5 grams left? What are you other 87.5 grams now?

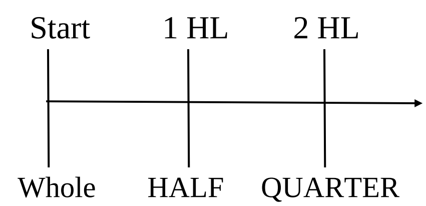
This diagram shows that starting with 100 g, and halving that over and over, it takes 3 half lives to get to 12.5 g. Each half life is 12.36 hours, so
12.36 hours x 3 = 37.08 hours



3. Someone hands you 512 grams of P-32 and you misplace it in your messy garage for a while. When you find it you find that only 2.0 grams of the stuff remains. How long has it been lost?
Each half life is 14.28 days, so
14.28 days X 8 = 114.24 days



4. If a scientist finds a frozen horse and measures that is contains only one quarter of the radioactive C-14 present that normal, that scientist could state that this horse died how many years ago?
Here, 2 half lives have past since this horse has eaten. C-14 half life is 5715 years, so, 5715 years X 2 = 11,430 years (give or take) have passes since he died.



5. Compare and contrast FISSION and FUSION reactions. Fission reactions are where larger isotopes are bombarded with neutrons, causing them to “split” into smaller atoms, releasing enormous amounts of energy. Fusion reactions crush small atoms (usually hydrogen atoms) into Helium atoms, also releasing even crazier amounts of energy.

6. Explain what is meant by this expression: $e=mc^2$ Energy is equal to mass (times the speed of light squared — which is a constant). This equation from Albert Einstein helps to explain the “loss” of mass in a nuclear fusion or fission reaction, showing how it is converted into energy. The important part is energy = mass, energy is the SAME THING as mass.

7. What is mass defect? In fission and fusion reactions, there is a very small loss of mass (associated with the change in the forces holding together the larger nuclei). This mass is not “lost” but it is converted into energy (and can be accounted for precisely with some complex math). Energy (and matter) cannot be destroyed, but in this case, can be converted into energy.

8. Compare and contrast natural and artificial transmutation. Natural transmutation is when a radioisotope decays without any “help” from a scientist. If scientists “bombard” a larger atom with neutrons (for example) which causes a fission reaction, that was artificial transmutation.

9. Define HALF LIFE. Radiation is emitted at a certain rate that cannot (yet) be altered by scientists. The individual radioisotopes seem to “choose for themselves” which will emit, and which won’t. What scientists have been able to calculate is how long it takes for HALF of a given radioisotope to emit radiation (and decay into something else). The timeframe for exactly HALF of a mass of radioactive isotope to decay is said to be it’s half life. This can be a second long, or a billion years. All half life times are different..

10. Define ISOTOPE vs. RADIOISOTOPE All atoms are isotopes, they just have different numbers of neutrons of other types of that element. Radioisotopes are “radioactive” or unstable. They emit radiation in an attempt to alter their neutron to proton ratio to a more stable ratio than they have at present.

11. Define Radioactivity. When an unstable nucleus in an unstable atom (a radioisotope) decides to try to change the neutron to proton ratio, it emits particles or energy, or both at the same time, in order to do this. The energy or particles emitted in this process is called radiation.

12. What makes an isotope’s nucleus unstable? The ratio of neutrons to protons determines stability of the nucleus. Smaller atoms have “about” a 1:1 neutron: proton ratio. Larger atoms have a slightly greater number of neutrons to protons and remain stable. The largest atoms that are stable have a $1\frac{1}{2}\ n^o : 1p^+$ ratio