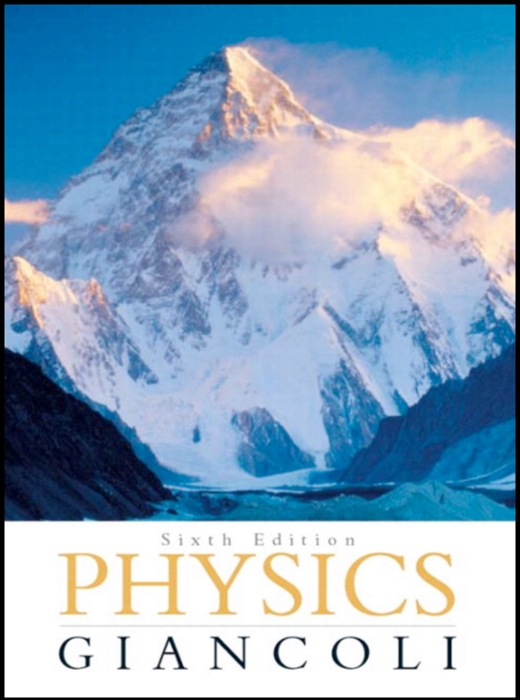



# ConcepTest PowerPoints

## Chapter 30

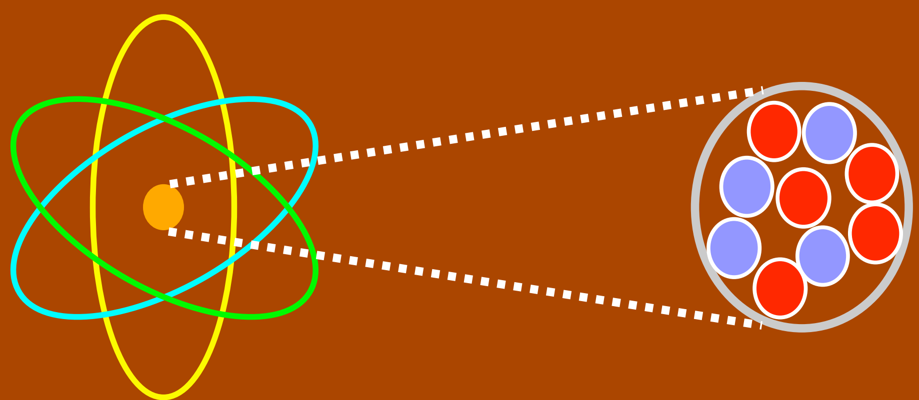
## *Physics: Principles with Applications, 6th edition*

## Giancoli

# *ConcepTest 30.1* The Nucleus

There are 82 protons in a lead nucleus. Why doesn't the lead nucleus burst apart?

1) Coulomb repulsive force doesn't act inside the nucleus
2) gravity overpowers the Coulomb repulsive force inside the nucleus
3) the negatively charged neutrons balance the positively charged protons
4) protons lose their positive charge inside the nucleus
5) none of the above

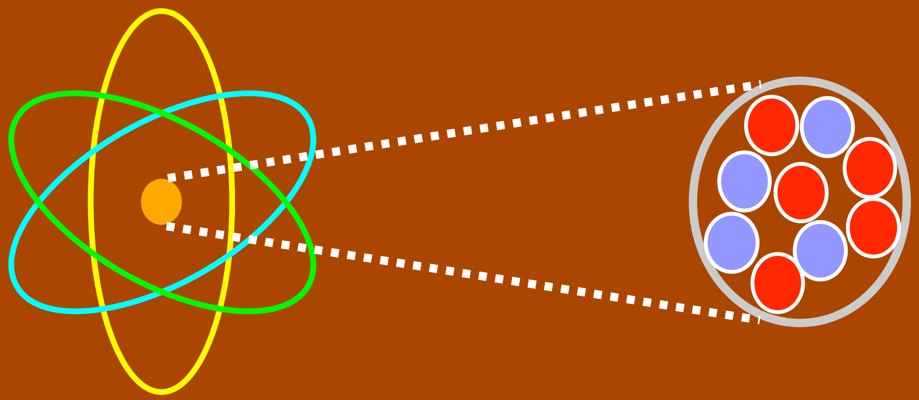


# *ConcepTest 30.1* The Nucleus

There are 82 protons in a lead nucleus. Why doesn't the lead nucleus burst apart?

1) Coulomb repulsive force doesn't act inside the nucleus
2) gravity overpowers the Coulomb repulsive force inside the nucleus
3) the negatively charged neutrons balance the positively charged protons
4) protons lose their positive charge inside the nucleus
5) none of the above

The Coulomb repulsive force is overcome by the even stronger ***nuclear force***!



## *ConcepTest 30.2a* Binding Energy I

What weighs more, an electron and a proton, or a hydrogen atom?

1) electron and proton
2) hydrogen atom
3) both the same

# *ConcepTest 30.2a* Binding Energy I

What weighs more, an electron and a proton, or a hydrogen atom?

1) electron and proton
2) hydrogen atom
3) both the same

The total energy (or mass) of a hydrogen atom must be *less* than the energies (or masses) of the electron plus the proton individually in order for the electron to be bound.

# *ConcepTest 30.2b* Binding Energy II

What is the total energy (or mass) of the hydrogen atom in its ground state?

1) 13.6 eV
2) $m_p c^2 + m_e c^2 + 13.6$ eV
3) $m_p c^2 + m_e c^2$
4) $m_p c^2 + m_e c^2 - 13.6$ eV

# *ConcepTest 30.2b* Binding Energy II

What is the **total energy** (or mass) of the hydrogen atom in its ground state?

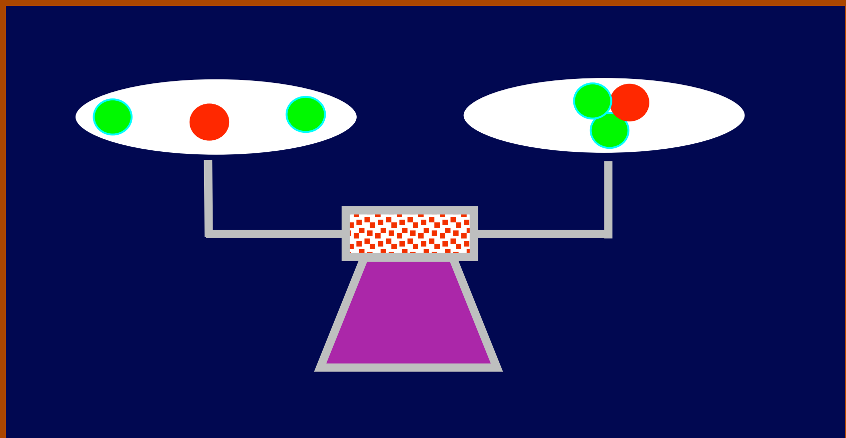
1) 13.6 eV
2) $m_pc^2 + m_ec^2 + 13.6$ eV
3) $m_pc^2 + m_ec^2$
4) $m_pc^2 + m_ec^2 - 13.6$ eV

The total energy (or mass) of a hydrogen atom must be *less* than the energies (or masses) of the electron plus the proton individually in order for the electron to be bound. **The mass difference is the binding energy.**

# *ConcepTest 30.2c* Binding Energy III

On a balance scale, you put **2 neutrons** and **1 proton** on one side and you put a **tritium** nucleus ($^3H$) on the other. Which side weighs more?

1) the 2 neutrons and 1 proton
2) the tritium nucleus
3) they both weigh the same
4) it depends on the specific isotope of tritium



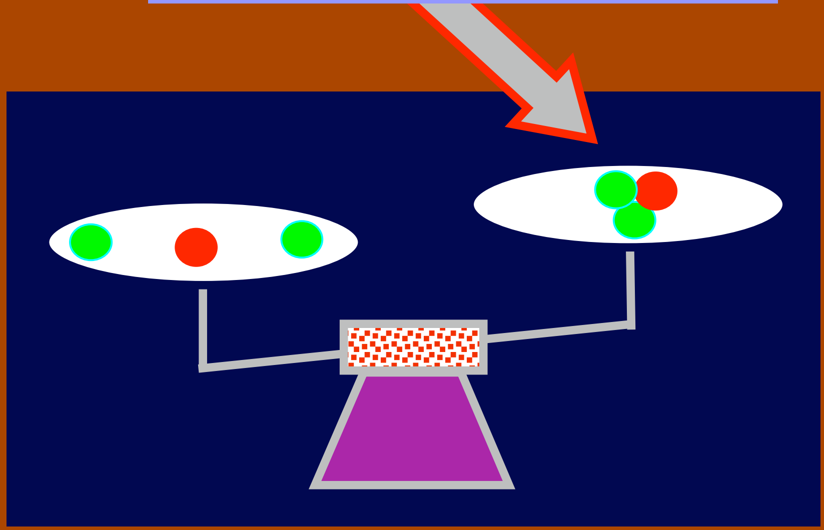
# ConcepTest 30.2c Binding Energy III

On a balance scale, you put 2 neutrons and 1 proton on one side and you put a tritium nucleus ($^3H$) on the other. Which side weighs more?

1) the 2 neutrons and 1 proton
2) the tritium nucleus
3) they both weigh the same
4) it depends on the specific isotope of tritium

The mass of the 2 neutrons and 1 proton is *less* when they are bound together as tritium. **The mass difference is the binding energy.**

need to *add* 8.5 MeV to balance scale



## *ConcepTest 30.3* Separation Energy

Does it take more energy to remove one proton or one neutron from $^{16}O$?

1) removing a proton takes more energy
2) removing a neutron takes more energy
3) both take the same amount of energy

# *ConcepTest 30.3* Separation Energy

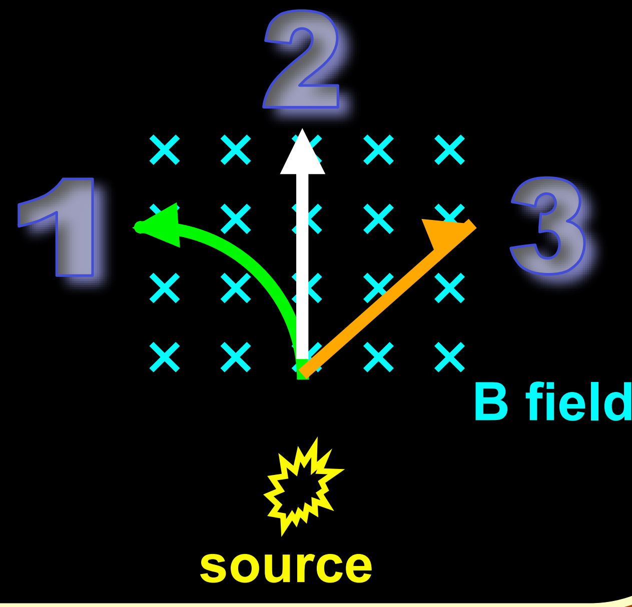
Does it take more energy to remove one proton or one neutron from $^{16}O$?

1) removing a proton takes more energy
2) removing a neutron takes more energy
3) both take the same amount of energy

Removing a proton takes *less* energy because the repulsive Coulomb force between positively charged protons helps to push the proton out of the nucleus. Remember that neutrons are uncharged.

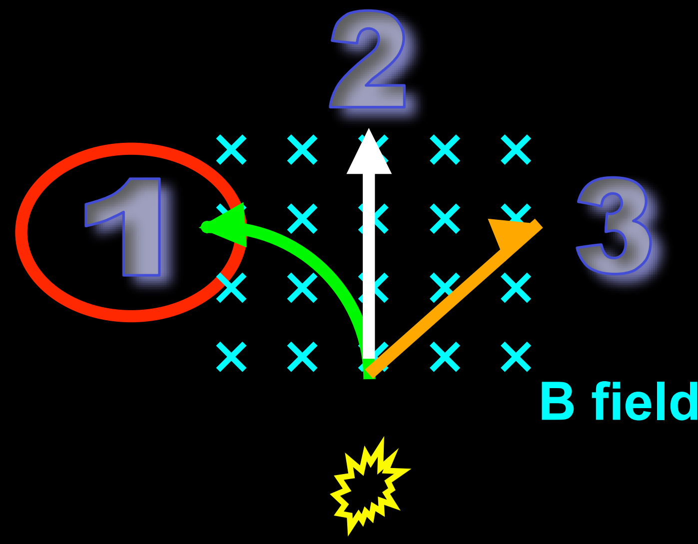
# *ConcepTest 30.4a* Particle Emission I

A radioactive substance decays and the emitted particle passes through a uniform magnetic field pointing into the page as shown. In which direction are alpha particles deflected?

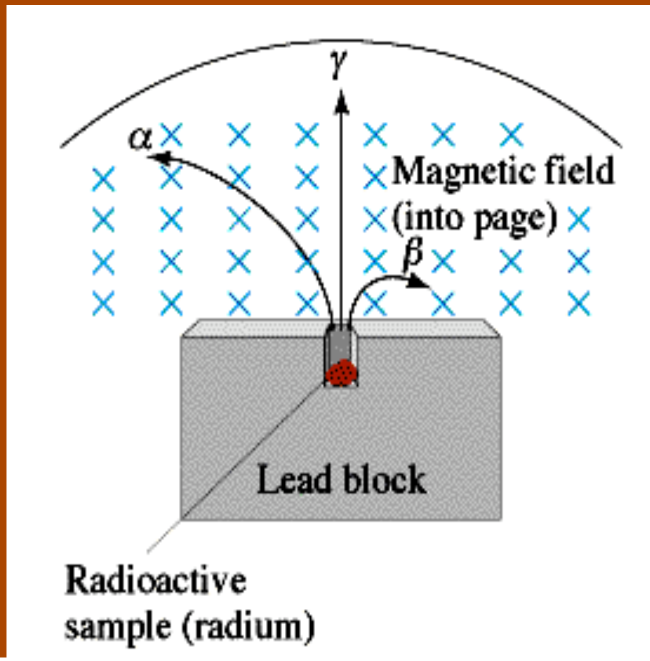


# ConcepTest 30.4a Particle Emission I

A radioactive substance decays and the emitted particle passes through a uniform magnetic field pointing into the page as shown. In which direction are alpha particles deflected?

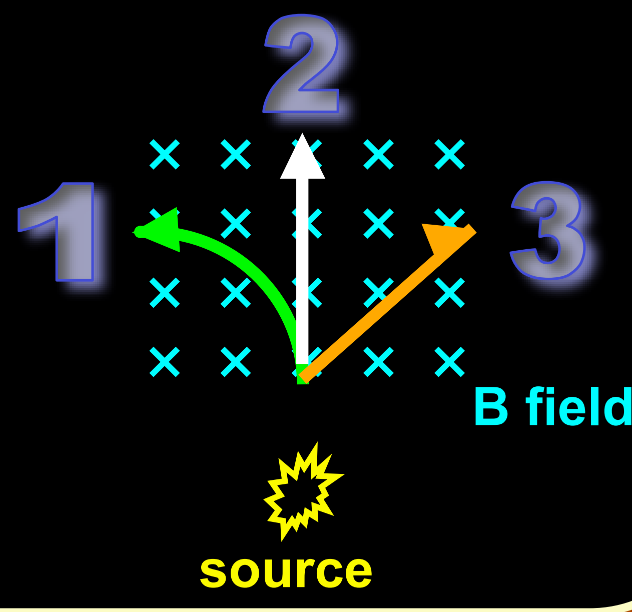



Using the right-hand rule, we find that positively charged particles (alpha particles) are deflected to the left.



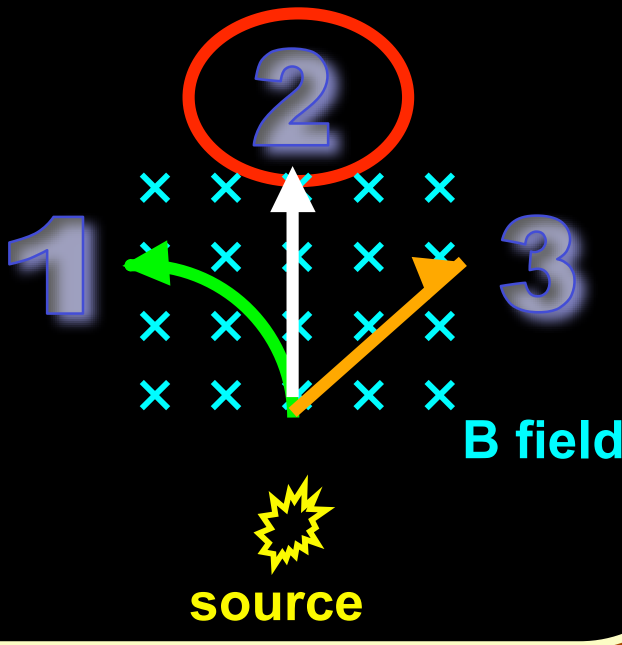
# ConcepTest 30.4b Particle Emission II

A radioactive substance decays and the emitted particle passes through a uniform magnetic field pointing into the page as shown. In which direction are gamma rays deflected?

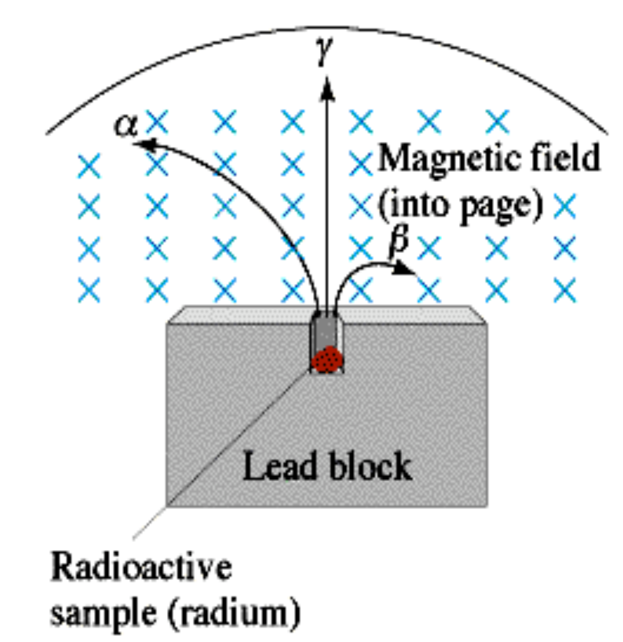


# *ConcepTest 30.4b* Particle Emission II

A radioactive substance decays and the emitted particle passes through a uniform magnetic field pointing into the page as shown. **In which direction are gamma rays deflected?**




**Gamma rays are uncharged, so they will not be deflected by a magnetic field.**




**Follow-up: What particles are bent to the right?**

## *ConcepTest 30.5* Radioactive Decay Energy

A radioactive nucleus undergoes gamma decay. How large would you expect the energy of the emitted photon to be?

1) less than 13.6 eV
2) 13.6 eV
3) hundreds of eV
4) millions of eV
5) billions of eV

## *ConcepTest 30.5* Radioactive Decay Energy

A radioactive nucleus undergoes gamma decay. How large would you expect the energy of the emitted photon to be?

1) less than 13.6 eV
2) 13.6 eV
3) hundreds of eV
4) millions of eV
5) billions of eV

The binding energy of nuclei is of the order *several MeV* (millions of eV). So, we would expect the energy of gamma decay to be in the same ballpark.

**Follow-up: What process could release a photon with billions of eV?**

# *ConcepTest 30.6a* Alpha Decay I

A uranium nucleus $^{238}U$ (initially at rest) decays into a thorium nucleus $^{234}Th$ and an alpha particle. Which one has the greater momentum?

1) the $^{234}Th$ nucleus
2) the alpha particle
3) both the same

# *ConcepTest 30.6a* Alpha Decay I

A uranium nucleus $^{238}U$ (initially at rest) decays into a thorium nucleus $^{234}Th$ and an alpha particle. Which one has the greater momentum?

1) the $^{234}Th$ nucleus
2) the alpha particle
3) both the same

By momentum conservation, they must have the same magnitude of momentum since the initial momentum was zero.

**Follow-up:** In what directions are the two products emitted?

# *ConcepTest 30.6b* Alpha Decay II

A uranium nucleus $^{238}U$ (initially at rest) decays into a thorium nucleus $^{234}Th$ and an alpha particle. Which one has the greater velocity?

1) the $^{234}Th$ nucleus
2) the alpha particle
3) both the same

# ConcepTest 30.6b Alpha Decay II

A uranium nucleus $^{238}U$ (initially at rest) decays into a thorium nucleus $^{234}Th$ and an alpha particle. Which one has the greater velocity?

1) the $^{234}Th$ nucleus
2) the alpha particle
3) both the same

The momentum is *mv* and is the same for both, but the alpha particle has the smaller mass, so it has the larger velocity.

# *ConcepTest 30.6c* Alpha Decay III

A uranium nucleus $^{238}U$ (initially at rest) decays into a thorium nucleus $^{234}Th$ and an alpha particle. Which one has the greater kinetic energy?

1) the $^{234}Th$ nucleus
2) the alpha particle
3) both the same

# ConcepTest 30.6c Alpha Decay III

A uranium nucleus $^{238}U$ (initially at rest) decays into a thorium nucleus $^{234}Th$ and an alpha particle. Which one has the greater kinetic energy?

1) the $^{234}Th$ nucleus
2) the alpha particle
3) both the same

The kinetic energy 1/2 $mv^2$ can be written as KE = $p^2/2m$. The momentum is the same for both, but the alpha particle has the smaller mass, so it has the larger KE.

# *ConcepTest 30.7* Beta Decay

What element results when $^{14}C$ undergoes **beta decay**?

1) $^{15}C$
2) $^{15}N$
3) $^{14}C$
4) $^{14}N$
5) $^{15}O$

# ConcepTest 30.7 Beta Decay

What element results when $^{14}C$ undergoes **beta decay**?

1) $^{15}C$
2) $^{15}N$
3) $^{14}C$
4) $^{14}N$
5) $^{15}O$

The reaction is: $^{14}_{6}C \rightarrow ^{14}_{7}N + e^{-} + \text{neutrino}$

Inside the nucleus, the reaction $n \rightarrow p + e^{-} + \nu$ has occurred, changing a neutron into a proton, so the atomic number Z increases by 1. However the mass number (A = 14) stays the same.

**Follow-up:** How would you turn $^{14}C$ into $^{15}N$?

## *ConcepTest 30.8a* Radioactive Decay Law I

You have 16 kg of a radioactive sample with a certain half-life of 30 years. How much is left after 90 years?

(1) 8 kg

(2) 4 kg

(3) 2 kg

(4) 1 kg

(5) nothing

# *ConcepTest 30.8a* Radioactive Decay Law I

You have **16 kg** of a radioactive sample with a certain half-life of **30 years**. How much is left after **90 years**?

(1) 8 kg

(2) 4 kg

(3) 2 kg

(4) 1 kg

(5) nothing

The total time (**90 years**) is **3 half-lives**.

After one half-life ⇒ 8 kg left.

After two half-lives ⇒ 4 kg left.

After three half-lives ⇒ 2 kg left.

**Follow-up:** When will the sample be reduced to nothing?

## *ConcepTest 30.8b* Radioactive Decay Law II

You have **12 kg** of a radioactive substance. **Ten years later**, you find that you only have **3 kg** left. Find the half-life of the material.

(1) 20 years

(2) 10 years

(3) 7.5 years

(4) 5 years

(5) 2.5 years

# *ConcepTest 30.8b* Radioactive Decay Law II

You have 12 kg of a radioactive substance. Ten years later, you find that you only have 3 kg left. Find the half-life of the material.

(1) 20 years

(2) 10 years

(3) 7.5 years

(4) 5 years

(5) 2.5 years

After one half-life $\Rightarrow$ 6 kg left.

After two half-lives $\Rightarrow$ 3 kg left.

So if the total time is 10 years, then the half-life must be 5 years.

(2 half-lives = 10 years)

**Follow-up: How much of the sample is left after another 10 years?**

## *ConcepTest 30.8c* Radioactive Decay Law III

You have 400 g of a radioactive sample with a half-life of 20 years. How much is left after 50 years?

1) more than 100 g
2) 75 - 100 g
3) 75 g
4) 50 - 75 g
5) less than 50 g

# ConcepTest 30.8c Radioactive Decay Law III

You have **400 g** of a radioactive sample with a half-life of **20 years**. How much is left after **50 years**?

1) more than 100 g
2) 75 - 100 g
3) 75 g
4) 50 - 75 g
5) less than 50 g

Total time (50 years) is 2 1/2 half-lives.

After one half-life ⇒ 200 g left

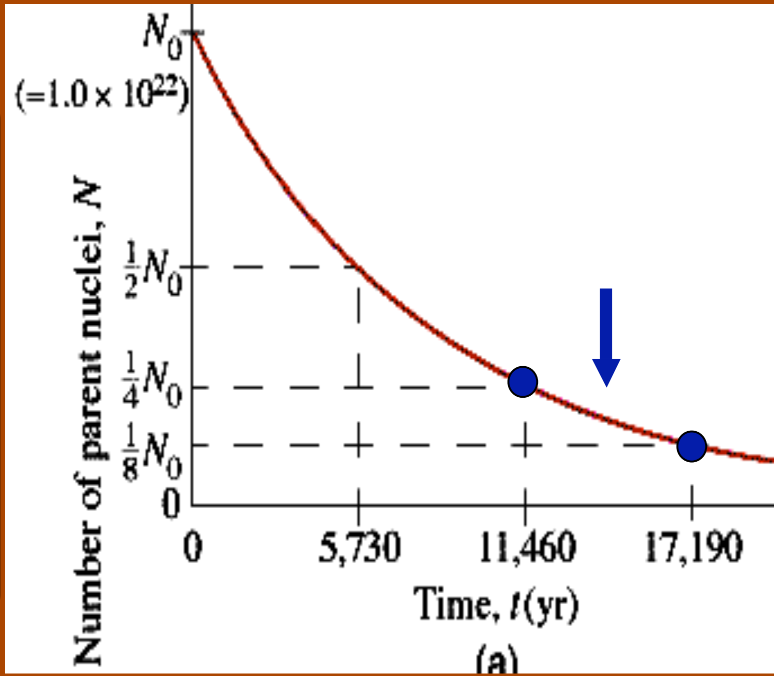
After two half-lives ⇒ 100 g left.

After three half-lives ⇒ 50 g left.

So after 2 1/2 half-lives ⇒ 75 g left ?

*No!!* Exponential function is not linear!

$$N = N_o e^{-(0.693 / T_{1/2})t} \Rightarrow$$ 70.7 g left



## *ConcepTest 30.8d* Radioactive Decay Law IV

You have two samples, A ($T_{1/2}$ = 10 yr) and B ($T_{1/2}$ = 20 yr) with initially different amounts. The initial amount of sample A is *64 kg,* while the amount of sample B is unknown. If you observe that the 2 amounts are equal after 40 years, what is the initial amount of B?

1) 64 kg
2) 32 kg
3) 16 kg
4) 8 kg
5) 4 kg

# ConcepTest 30.8d Radioactive Decay Law IV

You have two samples, A ($T_{1/2}$ = 10 yr) and B ($T_{1/2}$ = 20 yr) with initially different amounts. The initial amount of sample A is *64 kg,* while the amount of sample B is unknown. If you observe that the 2 amounts are equal after 40 years, what is the initial amount of B?

1) 64 kg
2) 32 kg
3) 16 kg
4) 8 kg
5) 4 kg

For sample A, after 40 years (4 half-lives), there is 4 kg left.
Now work backwards from there, for sample B:
40 years is 2 half-lives, so sample B initially had 16 kg.

**Follow-up: When will the samples again have equal amounts?**

# *ConcepTest 30.9a* Activity and Half-Life I

You have **10 kg** each of a radioactive **sample A** with a half-life of **100 years**, and another **sample B** with a half-life of **1000 years**. Which sample has the **higher activity**?

1) sample A
2) sample B
3) both the same
4) impossible to tell

# ConcepTest 30.9a Activity and Half-Life I

You have 10 kg each of a radioactive sample A with a half-life of 100 years, and another sample B with a half-life of 1000 years. Which sample has the higher activity?

1) sample A
2) sample B
3) both the same
4) impossible to tell

If a sample has a shorter half-life, this means that it decays more quickly (larger decay constant $\lambda$) and therefore has a higher activity:

$$\Delta N/\Delta t = -\lambda N$$

In this case, that is sample A.

**Follow-up:** What is the ratio of activities for the two samples?

## *ConcepTest 30.9b* Activity and Half-Life II

The same amount of two different radioactive samples A and B is prepared. If the initial activity of sample A is 5 times larger than that of sample B, how do their half-lives compare?

1) $T_{1/2}$ of A is 5 times larger than B
2) half-lives are the same
3) $T_{1/2}$ of A is 5 times smaller than B

# *ConcepTest 30.9b* Activity and Half-Life II

The same amount of two different radioactive samples A and B is prepared. If the initial activity of sample A is 5 times larger than that of sample B, how do their half-lives compare?

1) $T_{1/2}$ of A is 5 times larger than B
2) half-lives are the same
3) $T_{1/2}$ of A is 5 times smaller than B

A larger activity means that a sample decays more quickly, and this implies a shorter half-life.