Midterm 2 review

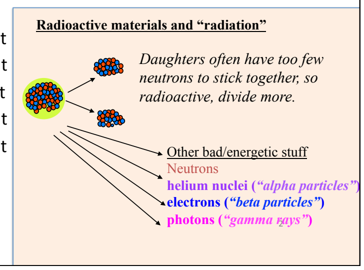
Day 15:
Any final questions about nukes?
Review

Reminders:
No HW this week!
Today's lecture in full on website after class
Extra HelpRoom review Wed 2-4p
Thursday Exam here…

An odd world…

You find yourself in some diabolical plot where you are given an alpha (α) source, beta (β) source, and gamma (γ) source. You must eat one, put one in your pocket and hold one in your hand. You …

a) α hand, β pocket, γ eat
b) β hand, γ pocket, α eat
c) γ hand, α pocket, β eat
d) β hand, α pocket, γ eat
e) α hand, γ pocket, β eat



Mid term on Thursday

- Balcony areas will be CLOSED on Thursday
- 30 multiple choice questions (30 pts)
  - 1 Long Answer (out of 2!) (10pts)
- Total 40 points.
- There will be no early or late exams given and no make-up exams.
- Exam will be closed book.
- TWO 3 by 5 inch formula cards. You can WRITE anything on it BY HAND. Please write your student ID on your formula card.
- Calculator and pencil/eraser
  - Calculator cannot connect to outside world. No calculators on cell phones or laptops allowed.
  - No sharing of calculators.
  - A limited supply of spare calculators are available (no guarantees they work though!)
- Exam grades and solutions will be posted after the exam on D2L.

1010, Fall 2012,
Fun-Sheet Exercise 2.

Each m/c question is worth 1 pt. **YOU SHOULD ONLY PICK 1 of the 2** Long Answers for 10 pts:
30 pts M/C 10pts Long Answer. Total points = 40.

Beware of grabbing at a numerical answer simply because you happen to see that number as you are calculating. We are sneaky and put in choices that are numbers you are likely to produce if you are not sure how to do the problem correctly. For many problems, it is good to make a simple sketch to picture the problem correctly.

For all of these problems, assume that air resistance is not important *unless* you are told otherwise.

Conversions & Constants you may or may not need:

1 pound = 4.45 N 1 mph = 0.447 m/s. $g = 9.8\ m/s^2$ (but you can use $10\ m/s^2$)

density of water = $\rho_w = m / V = 1000\ kg / m^3$

Formulas you may or may not need.

$KE = ½\ m\ v^2$

$GPE = m\ g\ h$

$W = f\ d$

Power = E / t

$PV + ½ mv^2 + mgh = E_{total}$

$P + ½ \rho v^2 + \rho gh = E_{total}/V = E_{total\ per\ unit\ volume}$

To ensure that you properly understand the question, we strongly recommend that you make a sketch of the situation described by the problem before giving an answer.

Yellah

Write the color on your M/C answer sheet. Return both the answer sheet and the exam.

Midterm preparation

Prepare by:
review the review notes for day 15!
reviewing all the lecture notes (day 9-14), hw (4-6), and then book
apply the principles we have learned -- practice (HW, clicker questions etc.)
study with others
come to the help room

There are sample problems for you to review in addition to today. See web.

- Prepare by applying the principles we have learned – practice.
- You CANNOT memorize answers to specific questions.
- Make a formula card now with the important equations.
- Go over homeworks, class clicker questions, questions in the book (see 1010 website).
  - Not sure how to get the answer – take it to the helproom.

Midterm 2 summary

- Conservation of energy

$$W_{ext} - |W_{friction}| = \Delta PE + \Delta KE$$

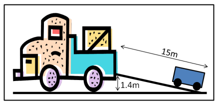
  - Work done by a force = F × $d_{//}$
  - Looked at work done by external forces and by friction
  - GPE = mgh, KE = ½ mv^2, PPE = PV, SPE= ½ kx^2, Thermal energy = constant × T
  - Ramps, roller coasters, balls…….
  - Power = energy/s
- Bernoulli's equation

$$E_{tpv} = P + ½ \rho v^2 + \rho gh$$

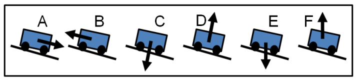
  - Conservation of energy for an incompressible fluid
- Nuclear Energy
  - potential energy wells of nucleus
  - Alpha decay
  - Fision & Fusion
  - Radioactivity

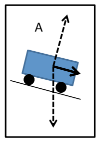
Conservation of energy

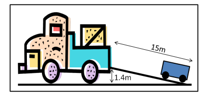
I'm moving boxes into the back of a truck that sits 1.4m above the ground. I use a 15m long ramp and a small cart to help me. When loaded, the cart has a mass of 20 kg. Friction is negligible.



What is the direction of the net force on the cart, when it is on the ramp and nobody is pushing it?



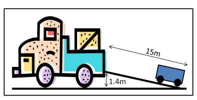




Cart mass = 20kg

If the cart has a mass of 20kg, how much PE does it gain when you push it up the ramp?

a. 274.4 J
b. 196 J
c. 28 J
d. 345. 8 J
e. 108.6 J



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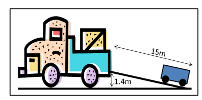
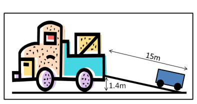
GPE = mgh = 20 kg (9.8 m/s^2) 1.4m



Cart mass = 20kg

What is the force required to push the cart up the ramp at a steady speed?

a. 196 N
b. 18.3 N
c. 0 N
d. 13.1 N
e. Something else



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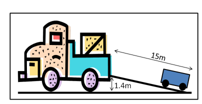
a. 196 N
b. 18.3 N
c. 0 N
d. 13.1 N
e. Something else

$W_{ext} - |\cancel{W_{fric}}| = \Delta GPE + \cancel{\Delta KE}$

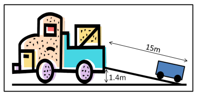
$F_{ext} \times d = mgh$
$F_{ext} = mgh/d$
$= 274.4 / 15 = 18.3$ N



Cart mass = 20kg

What length of ramp would I need if I could only push at a maximum force of 12 N?

a. 16.3 m
b. 18.3 m
c. 22.9 m
d. 28.2 m
e. Can't tell without more information



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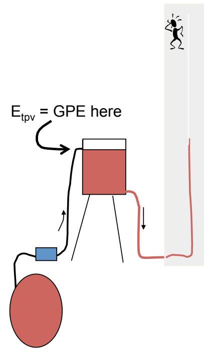
b. 18.3 m
c. 22.9 m
d. 28.2 m
e. Can't tell without more information

$F_{ext} \times d = mgh$
$d = mgh / F_{ext}$
$= 274.4 / 12 = 22.9$ m

Water distribution in skyscrapers

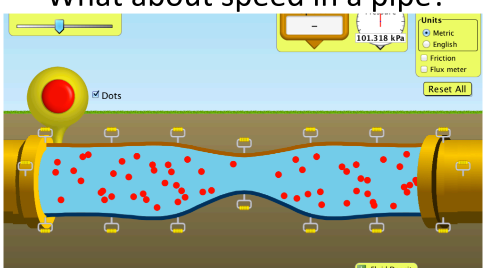


The skyscraper water problem:
- Less pressure on the higher floors,
- Water won't make it to the top floor….

How can you solve this problem?

- Put very high pressure pump at bottom (give water enough PPE at bottom)
- Use a series of pumps up the building
- Pump water to a tank on the roof, then you will always have pressure on the floors below.

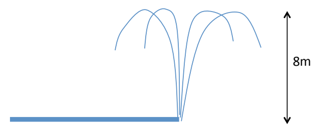
What about speed in a pipe?



$P + ½ \rho v^2 + \rho gh = E_{total}/V$ ($E_{total\ per\ unit\ volume}$)

http://phet.colorado.edu/en/simulation/fluid-pressure-and-flow

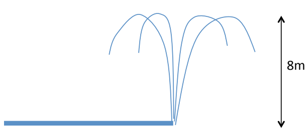
23



I'm designing a fountain for a city park. I want the water in the fountain to squirt 8m vertically in the air. What pressure will I need in the large pipe just before the nozzle? (Assume that friction can be ignored)

a. 8000 Pa
b. 80 Pa
c. 80,000 Pa
d. 12 000 Pa
e. More information required

$E_{tpv} = P + ½ \rho v^2 + \rho gh$



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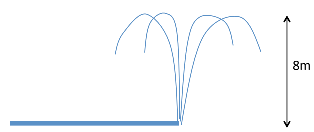
$E_{tpv} = P + ½ \rho v^2 + \rho gh$

Top of water jet: v = 0, P = 0, h = 8m
In pipe: v = 0, h = 0, P = ?

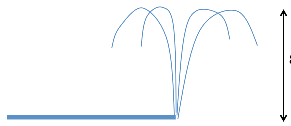
E_{tpv} is same in both locations

$P_{pipe} = \rho gh_{jet}$
$= 1000*10*8$
$= 80,000$ Pa



What is the speed of the water immediately after the nozzle?

a. ~15.3 m/s
b. ~12.5 m/s
c. ~8.7 m/s
d. ~ 4.3 m.s
e. Water does not come out



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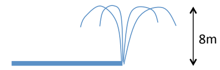
$E_{tpv} = P + ½ \rho v^2 + \rho gh$

Inside pipe: v = 0, P = 80,000 Pa, h = 0
After nozzle: v = ?, h = 0, P = 0

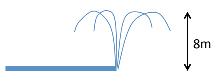
E_{tpv} is same in both locations

$P_{pipe} = ½ \rho v^2$
$v = \text{sqrt}(2P_{pipe}/\rho)$
= sqrt (2* 80,000 / 1,000)
= 12.6 m/s



If the fountain squirts 2m^3 of water in the air every second, what is the power produced by the pump that is supplying the pressurized water to the nozzle?

a. 78400 W
b. 2 W
c. 1000 W
d. 237,806 W
e. 156,800 W



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Power = energy supplied to water / sec
= GPE gained by water /sec
= mgh/s
= (m/s)×g×h

Mass of water squirted per second = 2m^3 × 1000kg/m^3
= 2000kg

Power = 2000 × 9.8 × 8
= 156,800 W

Recipe- how to make an atom:

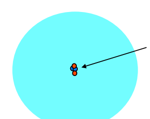
Ingredients: 1 teaspoon protons
1 teaspoon neutrons
1 cup of electrons

Proton (**positive charge**)
Neutron (no charge)

Electron
(**negative charge**)

1. Mix protons and neutrons thoroughly.
2. Bake at 100 million degrees until sticks together to form solid dense nucleus (about .0000001 s).
3. Frost with lightly with fluffy layer of negative electrons.

4. *Chill before serving!*



atom size:
Radius of nucleus is 10,000 times smaller than nucleus-electron distance

30

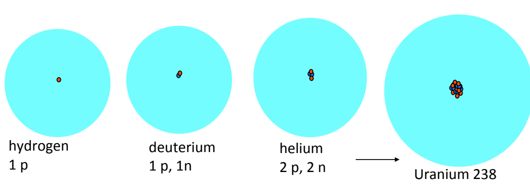
Each element has different number of protons.

Atom ingredients:

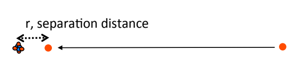
Proton (**positive charge**) – charge = 1.6 x 10^{-19} Coulombs
mass = 1.66 x 10^{-27} kg.

Neutron (no charge) – no charge
mass = 1.66 x 10^{-27} kg.

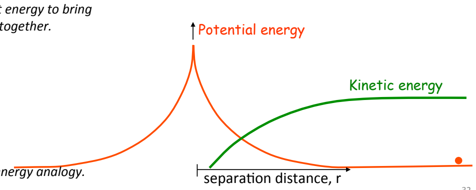
Electron (**negative charge**) – charge = -1.6 x 10^{-19} Coulombs
mass = 9.10 x 10^{-31} kg



What if threw proton so starts out going towards nitrogen nucleus with a lot of speed (lots of kinetic energy)?
Starts with lots of kinetic energy →
Repelling force from nucleus slows down proton →
Proton's kinetic energy converted into electrostatic potential energy, as it gets closer to nucleus



Potential energy curves- represent energy to bring particles together.

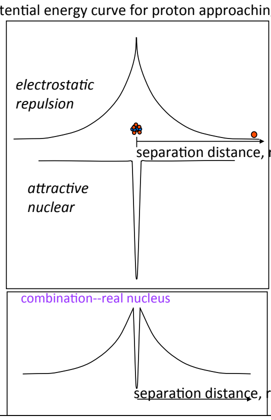


Gravity energy analogy.

if at center, want to roll down hill/fly apart … lots of electrostatic potential energy

32

Potential energy curve for proton approaching nucleus



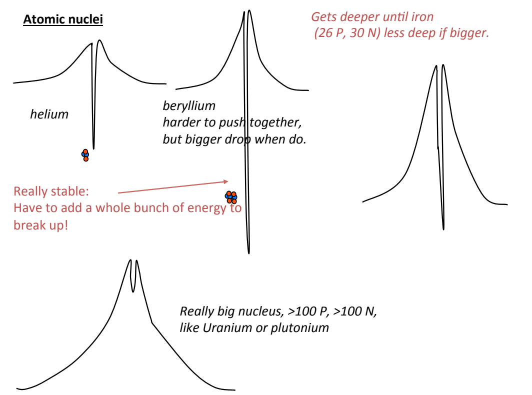
Energy scale gigantic compared to chemical energy.
Why? Simple coulomb's law.

$$F = \frac{k\,(\text{charge of \#1})(\text{charge of \#2})}{r^2}$$

Chemistry- forces between electrons and protons on distance scale of atomic size (> 10^{-10} m).

Nuclear forces- forces between protons on distance scale 10-100,000 times smaller.
10,000 times closer means forces **100,000,000 times bigger** because of $1/r^2$. Lots more potential energy stored!!!

33



34

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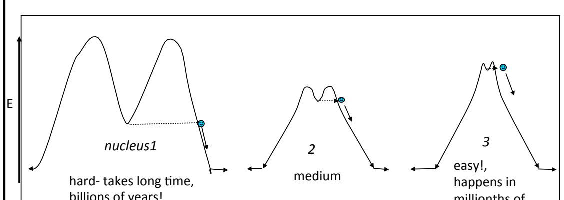
tunneling difficulty = width x depth of tunnel

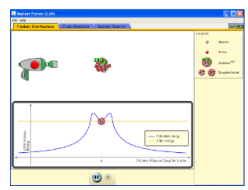


How much energy released?
a. 1 most, 2 second, 3 least
b. 2 most, 1, 3 least
c. 3 most, 2, 1 least
d. 3 most, 1, 2 least

energy is difference from bottom of crater to outside.
3 is most, 2 second, 1 is least

35

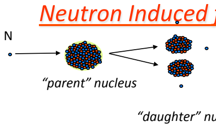
Another Sim
(because this is hard to do at home)



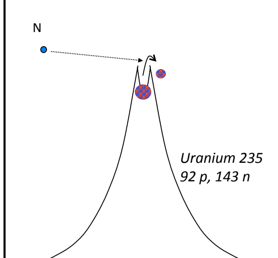
http://phet.colorado.edu/en/simulation/nuclear-fission

36

Neutron Induced fission- key to atomic bombs



- *two smaller nuclei*
- *few extra free neutrons*
- ***LOTS OF ENERGY!!***
- *(+sometimes other bad stuff)*

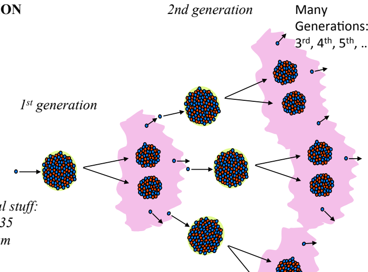


Neutron absorbed →
Excites U235 nucleus up above potential barrier →
Splits into two smaller nuclei…
which zoom apart due to electrostatic repulsion!

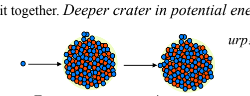
simulation

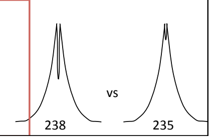
37

BACK TO CHAIN REACTION
Fission Nuclear explosion:
"atomic bomb"

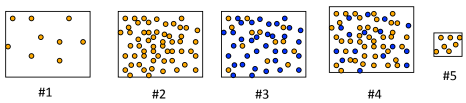


Why Ur 235 not 238? U 238 has 3 extra neutrons help hold it together. *Deeper crater in potential energy.*





U235 (orange) and U238 (blue) atoms are placed into a container, which are likely to result in a chain reaction (resulting in explosion) when a free neutron triggers fission of one of the U235:



a. #2 only
b. #1, #2, and #5
c. #2 and #4
d. #2, #3, and #4
e. #2, #4, and #5.

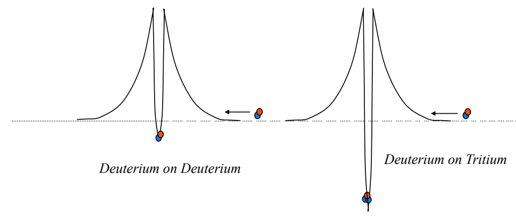
Lots of uranium in the ground… why not just blow up?

Correct answer is c. (#2 and #4) Analysis:
#1 is too sparse .. most neutrons will leave box before hitting another U235.
#2 is good.. Pure U235, densely packed, large package
#3 has too many U238's… more U238's than 235's. Free neutrons more likely to be absorbed by 238's than to hit and fission another 235.
#4 is OK … More U235's than 238's, still densely packed, large package
#5 is too small of package … neutrons likely to escape package before hitting another U235.

39

Fusion bomb or "hydrogen bomb"

Basic process like in sun. Stick small nuclei together.



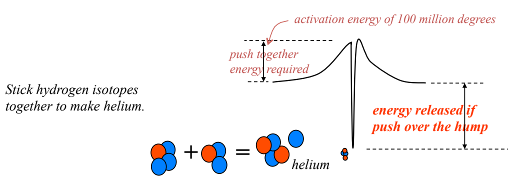
Which will release more energy during fusion?
a. Deuterium combining with deuterium
b. Deuterium combining with tritium

Answer is b. Incoming deuterium particle has comparatively more potential energy!

40

Fusion bomb or "hydrogen bomb"

Basic process like in sun. Stick small nuclei together.



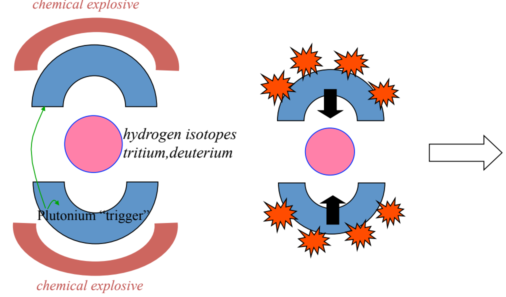
Simple if can push hard enough- just use sun or fission bomb.
More energy per atom than fission. Can use LOTS of hydrogen.

⇒End up with GIGANTIC bombs

1000 times bigger than first fission bombs

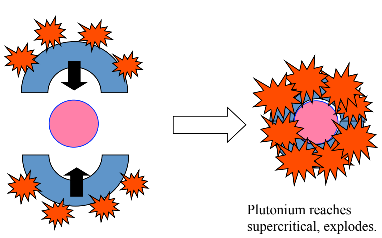
41

Fusion bomb (simple picture)



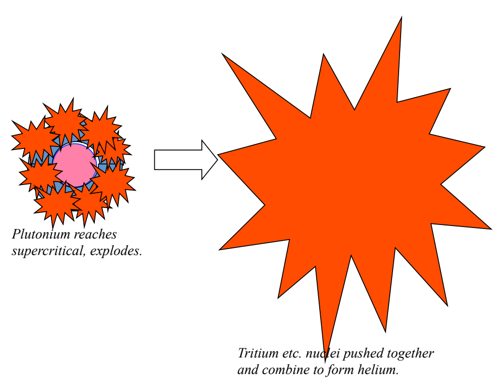
Shaped plutonium and assembled bombs at Rocky Flats.

42



Plutonium reaches supercritical, explodes. *(fission bomb)*

43



Plutonium reaches supercritical, explodes.

Tritium etc. nuclei pushed together and combine to form helium.

44

In atomic bomb, roughly 20% of Pl or Ur decays by induced fission
This means that after explosion there are

a. about 20% fewer atomic nuclei than before with correspondingly fewer total neutrons and protons,
b. 20% fewer at. nucl. but about same total neut. and protons.
c. about same total neutrons and protons and more atomic nuclei,
d. almost no atomic nuclei left, just whole bunch of isolated Neut.s and prot.s.,
e. almost nothing of Ur or Pl left, all went into energy.

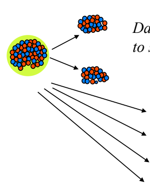
ans. c. Makes and spreads around lots of weird radioactive "daughter" nuclei (iodine etc.) that can be absorbed by people and plants and decay slowly giving off damaging radiation.
Lots of free neutrons directly from explosion can also induce radioactivity in some other nuclei.

45

Why are Nukes so destructive?

Huge amount of energy from separating the nuclei
In a short short time.
Thermal Energy
Pressure Waves
Radiation:
Alpha, beta and gamma radiation –
Emitted neutrons (also radiation) –
This radiation can be long-lived

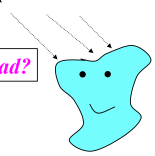
Radioactive materials and "radiation"



Daughters often have too few neutrons to stick together, so radioactive, divide more.

Other bad/energetic stuff that comes out.
Neutrons
electrons ("*beta particles*")
photons ("*gamma rays*")
helium nuclei ("*alpha particles*")

Why radiation bad?



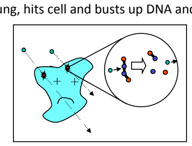
Jocell

47

Alpha particles: helium nuclei
- most of radiation is this type
- common is Radon (comes from natural decay process of U^{238}), only really bad because Radon is a gas .. Gets into lungs, if decays there bad for cell.

In air: Travels ~2 cm ionizing air molecules and slowing down …
eventually turns into He atom with electrons

If decays in lung, hits cell and busts up DNA and other molecules:

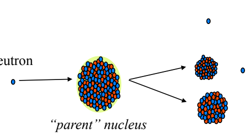


Usually doesn't get far -- because it hits things

Beta particles:
energetic electrons … behavior similar to alpha particles, but smaller and higher energy

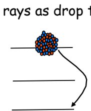
48

Sources of Gamma Radiation



- *two smaller nuclei*
- *few extra free neutrons*
- ***LOTS OF ENERGY!!***
- *(+sometimes other bad stuff)*

"daughter" nuclei – come out in *excited* nuclear energy state
…. Give off gamma rays as drop to lower energy.

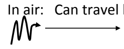


Jumps down in energy …
Gives off gamma ray…
VERY HIGH ENERGY PHOTON

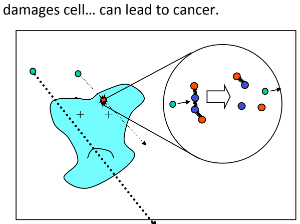
49

gamma rays: high-energy photons
- So high energy can pass through things (walls, your body) without being absorbed, but if absorbed really bad!

In air: Can travel long distances until absorbed



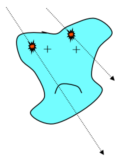
In body, *if* absorbed by DNA or other molecule in cell …
damages cell… can lead to cancer.



Most likely

If pass through without interacting with anything in cell then no damage.

50



But also can cure cancer- Concentrate radiation on cancer cells to kill them.

51

An odd world…

You find yourself in some diabolical plot where you are given an alpha (α) source, beta (β) source, and gamma (γ) source. You must eat one, put one in your pocket and hold one in your hand. You …

a) α hand, β pocket, γ eat
b) β hand, γ pocket, α eat
c) γ hand, α pocket, β eat
d) β hand, α pocket, γ eat
e) α hand, γ pocket, β eat

α - very bad, but easy to stop -- your skin / clothes stop it
β - quite bad, hard to stop -- pass into your body -- keep far away
γ- bad, but really hard to stop--- rarely rarely gets absorbed
Me--- I pick (d)---

52