+Daily Assignment Sheet

(check them off as you complete them)

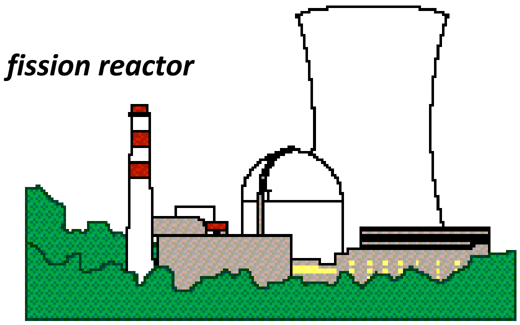
Name ________________________ Per ____

honors chemistry **packet 6**

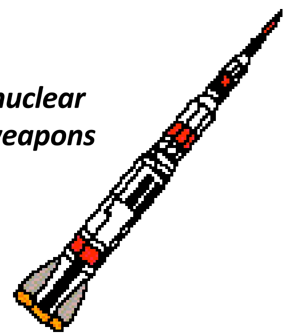
Nuclear Chemistry

Due Date	Assignment
Fri 12/3	___ Do WS 6.1
Mon 12/6	___ Do WS 6.2
	___ Do WS 6.3
Tue 12/7	___ start WS 6.4
Wed 12/8	___ Do WS 6.4
	___ Start WS 6.5
Thur 12/9	___ finish radiation lab?'s
Fri 12/10	* demo day * ***"Hot? Or Not?"***
Mon 12/13	___ Do WS 6.5
Tue 12/14	___ Do WS 6.6
Wed 12/15	___ Do WS 6.7
	___ Do WS 6.8 (review sheet)
	___ Do WS 6.9 (crossword puzzle)

fission reactor



nuclear weapons



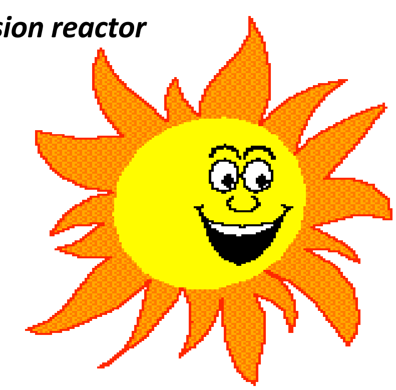
••• QUIZ TODAY •••

____ Come to class with packets ready to be turned in, with the above underlined assignments in proper order, in your pocket folder, with this page as the cover page & grade report inside. There will be a 1 point penality for not doing this. (-1/2 point for no name on top) Please don't turn in old packets (1/2 pt).

Packet Order

- assignment sheet
- WS 6.1 ~ 6.9 (in that order)

fusion reactor



+ WS 6.1 Nuclear Particles & Reactions

1. What causes radioactivity?

2. Types of nuclear reactions: Complete this chart from notes in class...

Natural Decay:

Induced:

Electron Capture:

Fission:

Fusion:

	particle name	symbol
(α)	alpha	
(β)	beta	
	positron	
	neutron	
	proton	
	deutron	
	gamma	γ

3. Label the following nuclear reactions as either fusion, fission, induced, natural decay, or electron capture:

a. ${}^{14}_{6}C$ ---> ${}^{14}_{7}N$ + ${}^{0}_{-1}e$ ______________________

b. ${}^{40}_{19}K$ + ${}^{0}_{-1}e$ ---> ${}^{40}_{18}Ar$ ______________________

c. ${}^{252}_{98}Cf$ ---> ${}^{142}_{56}Ba$ + ${}^{106}_{42}Mo$ + $4{}^{1}_{0}n$ ______________________

d. ${}^{9}_{4}Be$ + ${}^{4}_{2}He^{+2}$ ---> ${}^{12}_{6}C$ + ${}^{1}_{0}n$ ______________________

e. ${}^{6}_{3}Li$ + ${}^{12}_{6}C$ ---> ${}^{17}_{9}F$ + ${}^{1}_{0}n$ ______________________

f. ${}^{60}_{27}Co$ + β ---> ${}^{60}_{26}Fe$ ______________________

g. ${}^{4}_{2}He$ + ${}^{4}_{2}He^{+2}$ ---> ${}^{7}_{4}Be$ + ${}^{1}_{0}n$ ______________________

h. ${}^{235}_{92}U$ + ${}^{1}_{0}n$ ---> ${}^{144}_{55}Cs$ + ${}^{90}_{37}Rb$ + $2{}^{1}_{0}n$ ______________________

i. ${}^{233}_{92}U$ ---> ${}^{4}_{2}He^{+2}$ + ${}^{229}_{90}Th$ ______________________

j. ${}^{29}_{14}Si$ + ${}^{1}_{1}p$ ---> ${}^{30}_{15}P$ ______________________

Answer Bank:

fusion (1)

fission (2)

induced (3)

natural decay (2)

electron capture (2)

+ WS 6.2 - Nuclear Reactions

Complete each of the following nuclear reactions by determining the missing particle, then **name that particle** ("alpha particle" or "uranium-233", etc...) #1 is an example...

symbol	name
${}^{4}_{2}\text{He}^{+2}$ or α	alpha particle (a helium nucleus)
${}^{0}_{-1}\text{e}$ or β	beta particle (an electron)
${}^{0}_{+1}\text{e}$	positron (a positive electron?!)
${}^{1}_{0}\text{n}$	neutron
${}^{1}_{1}\text{p}$ or ${}^{1}_{1}\text{H}^{+1}$	proton (hydrogen-1 nucleus)
${}^{2}_{1}\text{H}^{+1}$	deutron (hydrogen-2 nucleus)

1. ${}^{14}_{6}\text{C}$ ---> ${}^{14}_{7}\text{N}$ + [${}^{0}_{-1}\text{e}$] beta particle

2. [ ] + ${}^{0}_{-1}\text{e}$ ---> ${}^{40}_{18}\text{Ar}$ ________________

3. ${}^{252}_{98}\text{Cf}$ ---> [ ] + ${}^{106}_{42}\text{Mo}$ + $4\,{}^{1}_{0}\text{n}$ ________________

4. ${}^{9}_{4}\text{Be}$ + [ ] ---> ${}^{12}_{6}\text{C}$ + ${}^{1}_{0}\text{n}$ ________________

5. ${}^{6}_{3}\text{Li}$ + ${}^{12}_{6}\text{C}$ ---> ${}^{17}_{9}\text{F}$ + [ ] ________________

6 ${}^{60}_{27}\text{Co}$ + [ ] ---> ${}^{60}_{26}\text{Fe}$ ________________

7. ${}^{4}_{2}\text{He}$ + ${}^{4}_{2}\text{He}$ ---> ${}^{7}_{4}\text{Be}$ + [ ] ________________

8. ${}^{235}_{92}\text{U}$ + ${}^{1}_{0}\text{n}$ ---> ${}^{144}_{55}\text{Cs}$ + ${}^{90}_{37}\text{Rb}$ + [ ] ________________

9. [ ] ---> ${}^{4}_{2}\text{He}$ + ${}^{229}_{90}\text{Th}$ ________________

10. ${}^{29}_{14}\text{Si}$ + [ ] ---> ${}^{30}_{15}\text{P}$ ________________

11. ${}^{40}_{19}\text{K}$ + ${}^{1}_{0}\text{n}$ ---> ${}^{41}_{18}\text{Ar}$ + [ ] ________________

12. ${}^{24}_{12}\text{Mg}$ + [ ] ---> ${}^{22}_{11}\text{Na}$ + α ________________

13. ${}^{230}_{90}\text{Th}$ + β ---> ${}^{223}_{84}\text{Po}$ + **2** ${}^{2}_{1}\text{H}^{+1}$ + [ ] ____________________

14. ${}^{246}\text{Pu}$ + ${}^{1}_{0}\text{n}$ ---> ${}^{98}\text{Mo}$ + [ ] + **5** ${}^{1}_{0}\text{n}$ ________________ (find the atomic #'s!)

15. Write the reaction for a Rn-224 atom undergoing 1 beta decay: What is the daughter? _______

16. Write the reaction for a Po-218 atom undergoing 1 alpha decay: What is the daughter? _______

17. What particle is produced when a U-234 atom undergoes a series of <u>two</u> alpha decays **and** <u>three</u> beta decays?

18. Pb-210 undergoes a series of alpha and beta decays to end up eventually as Ir-198. How many alpha particles and how many beta particles were emitted in all? Hint: do alpha's first, then beta's. α = ______ β = ______ (show work)

Ans(IRO) #1-17: alpha particle beta particle barium-142 deutron francium-224 lead-214 positron potassium-40 protactinium-226 proton 3-protons neutron neutron 2-neutrons tellurium-144 uranium-233

+ WS 6.3 Logarithms & Exponential Equations

$y = x^n$	In this equation, *n* is the **logarithm** of *y*.

For example, $10^3 = 1000$. Therefore, $\log 1000 = 3$.

Power Property of Logarithms: $\log x^n = n \log x$

Logarithms can be used to solve equations in which variables appear as exponents ***(exponential equations)***. To do this, you take the logarithm of both sides of the equation:

Example: Solve for x: $5^x = 100$

$\log 5^x = \log 100$ *(take log of both sides)*

$x \log 5 = \log 100$ *(power property of logs)*

$x = \dfrac{\log 100}{\log 5}$ *(solve for x)*

$x = 2.86$

Exercises: (solve for the variable, and show all steps)

1. $4^x = 64$

2. $2^n = 256$

3. $3^z = 264$

4. $72/15 = 2^n$

5. $2^x = 5024$

6. $3^n = 4.1 \times 10^5$

Ans (IRO+7): 2.26 3 4.18 5.08 5.53 8 11.4 11.8 12.3 20 42.9 58.1 flying postal cheese

+ WS 6.4 Radioactive Half-Life

$$\frac{m_i}{2^n} = m_f \qquad T = (t_{1/2})(n) \quad \text{(n=\# of half-lives)}$$

show all work!

Try #1 - #5 **without** using the equation:

1. Tritium (H-3) is a radioactive isotope of hydrogen with a half-life of 12.3 years. How long would it take for a 40.0 g sample to decay down to 1.25 g?

Ans: ________

2. Fe-61 has a half-life of 6.00 min. Of a 100.0 mg sample, how much will remain after 18.0 min?

Ans: ________

3. After 20.0 days, a 120 kg sample of Bi-210 decays down to just 7.5 kg. What is its half-life?

Ans: ________

4. What percent of a sample of a radioactive element whose halflife = 5.0 years will decay after 25 years?

Ans: ________

5. K-42 has a half-life of 12.0 hours. At present, a given ore sample contains 34.2 mg of K-42. How much did it contain yesterday at this same time?

Ans: ________

For the remaining 6 problems, use the half-life equations (above) to solve: (look up halflife on periodic table)

6. Tritium is hydrogen-3. Of a 24.0 mg sample, how much will remain after 9.25 years?

Ans: ________

7. How long will it take for a 80.0 g sample of cobalt-60 to decay down to 13.0 g?

Ans: ________

8. After 34.8 min, a 43.5 g sample of Fr-215 has decayed down to 10.0 g. Whatis its half-life?

Ans: ________

9. An ore sample is found to contain 3.45 g of K-40. How much did it contain 6.0 billion years ago?

Ans: ________

10. How long will it take for one mole of Na-22 to decay down to just one atom?
(hint- initial amount = 6.02×10^{23})

Ans: ________

11. What percent of a tritium (see #1) sample will decay in one day?

Ans: ________

Ans (IRO+3): 0.0154 5 12.5 13.8 14.2 16.4 29.9 61.5 89.1 93.5 96.9 137 162 205

Units (IRO+1): min min days years years years mg mg mg g g % %

+ WS 6.5 Carbon-14 Dating

In the spaces below, write and illustrate as though it were a comic strip, a description of the entire process of C-14 dating in the 6 squares provided, showing: **1)** how and where C-14 is produced, **2)** how it decays and establishes a small but constant level in the atmosphere, **3)** how this same level also becomes established in plants... **4)** and in animals, **5)** the significance of death, and **6)** how a Geiger counter can be used to determine the age of an artifact.

Be detailed enough so that someone else could understand these 6 steps.

1	2	3
4	5	6

1. In what ways is C-14 different than regular carbon (C-12)? Name at least two:

2. Do C-14 and C-12 react the same chemically? If no, explain why not. If yes, explain why.

(more questions on back!)

+ **WS 6.5** **(side 2)**

3. What's wrong with this statement: "When an animal dies, the C-14 inside it starts to decay, and then after a while you can tell how long it has been dead by using C-14 dating."

4. Rewrite the statement in #3 above to be more correct.

5. For each of the following, decide whether or not C-14 dating could be used.

• **If you answer no, explain why not!**

____ To determine the age of a bronze axe, believed to be 10,000 - 13,000 years old.

____ To determine the age of the oldest living pine tree believed to be 5,000 - 10,000 years old.

____ To determine the age of an animal skin, believed to be 3,000 - 4,000 years old.

____ To verify the age of a man claiming to be 6,493 years old.

____ To determine the time of death of a murder victim found last Tuesday.

____ To determine the age of a wooded spear, believed to be 100,000 - 120,000 years old.

6. If a newly cut piece of wood gives a C-14 Geiger tube reading of 124 cpm (counts per minute) and an artifact gives a reading of 31 cpm, how old is the artifact? **(don't use the half-life equation)**

7. If a newly cut piece of wood gives a C-14 Geiger tube reading of 124 cpm, and an artifact gives a reading of 47 cpm, how old is the artifact? **(use the half-life equation)**

8. If a newly cut piece of wood gives a C-14 Geiger tube reading of 124 cpm what reading would be given by an artifact that is... **(use the equation & show your work!)**

a) 18,500 years old? Ans: ______

b) 6 days old? Ans: ______

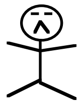
c) 435,000 years old? Ans: ______

Ans (IRO+3): N N N N N Y 1.74×10^{-21} 2.52 13.2 124 8020 11,460 23,920 cherry-tree mustache
Units (IRO): years, years, cpm, cpm, cpm

+WS 6.6 - Nuclear Reactors

Don Showalter's Miniature Evil Twin Brother (we'll simply call him "Mini-Walter") has erased key terms describing the function of a nuclear power plant. Fill in the blanks by choosing from the answer bank below.

Choose wisely!



In a nuclear reactor, ____________ undergoes nuclear ____________ when struck by ____________. This reaction releases many more ____________ which are capable of splitting many more ____________ atoms. If this ____________ is not controlled, it could cause a ____________. To prevent this, ____________ are used to absorb ____________, thus reducing the number available to cause ____________. A metal such as ____________ is often used for this, unlike ____________ which can vaporize at high temperatures.

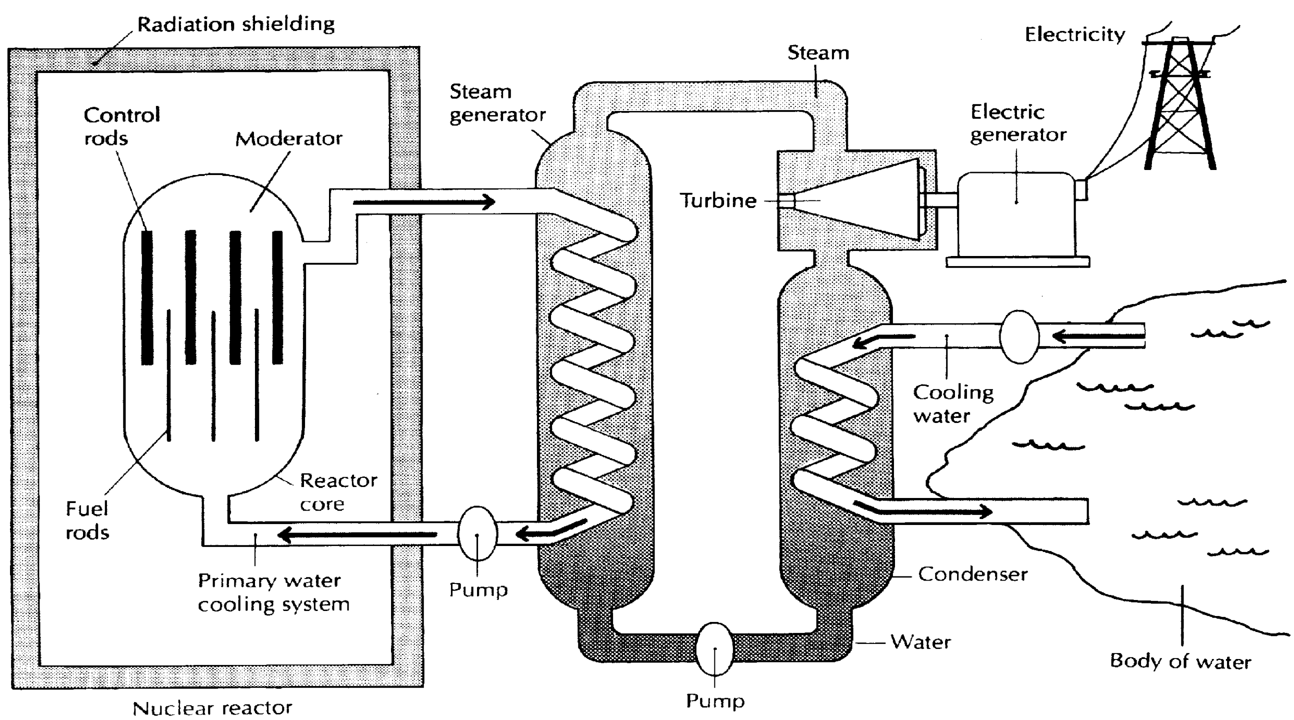
In the primary cooling system, water absorbs ____________ from the ____________, and transfers it to the ____________ which is part of the secondary cooling system. The water in the 1° cooling system also helps to regulate the ____________ of the reactor core.

In the secondary cooling system water is changed into ____________ by absorbing ____________ from the ____________. Once changed, the ____________ can turn a ____________ which operates a ____________, and this is what creates ____________. Eventually, the ____________ will have to be changed back into water by the tertiary cooling system.

In the tertiary cooling system, water from a ____________ may be used to absorb heat from the ____________ which is in the 2° cooling system. Once the water in the 3° is hot, it is sent to a ____________ before being returned to the ____________.

==== **Answers**: **In Alphabetical Order + 7** === *Cross Them Off As you Find Them!* ====

1° water system / 3° water system / carbon / cadmium / chain reaction / cobalt / condenser / control rods / cooling tower / electricity / explosion / fission / fission / generator / heat / heat / isotopes / meltdown / moderator / neutrons / neutrons / neutrons / reactor core / river / river / steam / steam / steam / steam / steam generator / temperature / turbine / U-235 / U-235 / U-238



1° water system 2° water system 3° water system

+WS 6.7 -- Effects & Applications of Nuclear Chemistry

Biological Effects

• acute (short term) damage

• chronic (long term) damage

• genetic damage

Application of Nuclear Chemistry

• preparation of artificial elements

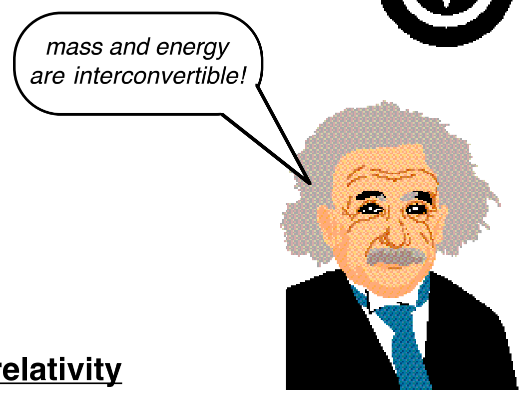
• radioactive dating

• radioactive tracers (labels)

• cancer treatment

• medical diagnosis

• food preservation



Einstein's theory of special relativity

Use table 20.3 & Einstein's famous equation E=mc2 to calculate the energy change (per mole) for the following nuclear reactions:

1. $^{2}_{1}H + ^{3}_{2}He \longrightarrow ^{4}_{2}He + ^{1}_{1}H$

$J = kg \bullet (m/s)^2$

$\Delta E = \Delta mc^2$

$^{A}_{Z}X$

$c = 3.00 \times 10^8$ m/s

2. $^{238}_{92}U \longrightarrow ^{234}_{90}Th + ^{4}_{2}He$

3. Plutonium-239 undergoing an alpha decay.

Table 20.3 Masses of Some Nuclei and Other Atomic Particles*

Symbol	Z	A	Mass (amu)	Symbol	Z	A	Mass (amu)
e^-	−1	0	0.000549	Co	27	59	58.9184
n	0	1	1.00867	Ni	28	58	57.9199
H or p	1	1	1.00728	Pb	82	206	205.9295
	1	2	2.01345		82	207	206.9309
	1	3	3.01550		82	208	207.9316
He	2	3	3.01493	Po	84	210	209.9368
	2	4	4.00150		84	218	217.9628
Li	3	6	6.01347	Rn	86	222	221.9703
	3	7	7.01435	Ra	88	226	225.9771
Be	4	9	9.00999	Th	90	230	229.9837
B	5	10	10.0102		90	234	233.9942
	5	11	11.0066	Pa	91	234	233.9931
C	6	12	11.9967	U	92	233	232.9890
	6	13	13.0001		92	234	233.9904
O	8	16	15.9905		92	235	234.9934
Cr	24	52	51.9273		92	238	238.0003
Fe	26	56	55.9206	Pu	94	239	239.0006

*The mass of an atom is obtained by adding the masses of the electrons to the nuclear mass given in this table. For example, the mass of the $^{12}_{6}C$ atom is 11.9967 + 6(0.000549) = 12.0000. (From R. C. Weast, ed., *CRC Handbook of Chemistry and Physics,* 59th ed. [Boca Raton, Fla.: CRC Press, Inc., 1978]. With permission of CRC Press, Inc.)

Ans (IRO+2): 4.14E11 5.13E11 -1.0071E12 1.764E12 2.181E12 **UNITS:** J, J, J

+ WS 6.8 Review

Determine the missing particle, and *label the following* as ec, natural decay, induced, fission, or fusion.

1. ${}^{243}_{97}Bk$ + ${}^{1}_{1}p$ ---> ${}^{96}_{40}Zr$ + ${}^{50}_{22}Ti$ + [ ] ________________________

2. [ ] + ${}^{0}_{-1}e$ ---> ${}^{26}_{14}Si$ ________________________

3. ${}^{108}Ag$ + ${}^{1}_{0}n$ ---> [ ] + ${}^{109}Ru$ ______________________ (hint: look-up atomic #'s)

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4. A francium-224 atom gets hit by a deutron (must have been a drive-by).
   What type of reaction is it? ________________What isotope is produced? _________________

5. A Pa-235 undergoes a series of alpha and/or beta decays to eventually become a Fr-227.
   How many alpha decays? _______ beta decays? _______

6. Zn-65 has a half-life of 244 days. What percent will decay in 1year?

7. If a newly cut piece of wood gives a C-14 Geiger tube reading of 150 cpm, and a wooden artifact gives reading of 65 cpm, how old is the artifact?

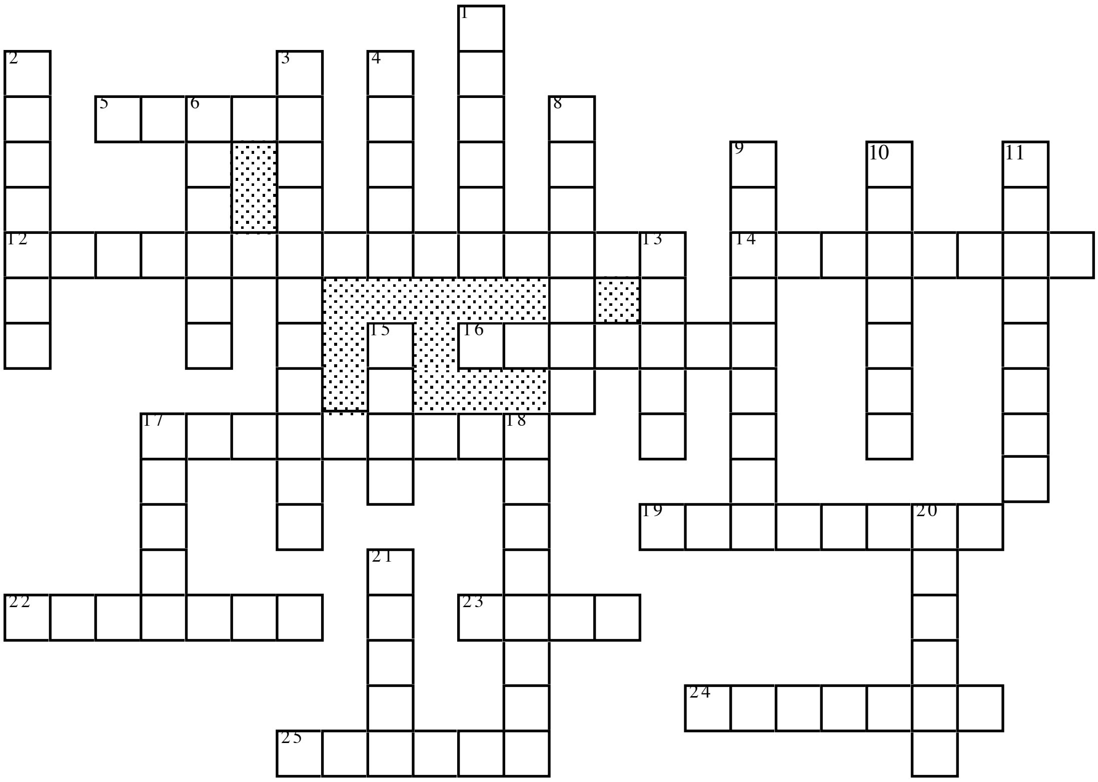
8. Explain 2 reasons why C-14 dating cannot be used to date the age of your pet cat.
   ("I don't have a pet cat" is not an acceptable answer)

9. Burns to the skin is an example of [acute / chronic / genetic] damage by radiation.

10. Calculate the energy change (per mole) for the following... Use the table on WS 6.7...
    ${}^{59}_{27}Co$ + ${}^{1}_{1}p$ ---> ${}^{58}_{28}Ni$ + **2** ${}^{1}_{0}n$

Ans (IRO+ 3): Fe-56 P-26 Kr-98 Ra-226 fission induced induced ec 37.1 64.5 6930 1.04 E 12

+ WS 6.9 Crossword Puzzle



Down

1. packets of electromagnetic radiation
2. radioisotopes used for medical purposes; they can be detected in the body by their radiation
3. an unstable atomic nucleus is ________________
4. type of radiation; very high in energy; very powerful
6. sub-atomic particle with positive charge
8. also known as hydrogen-3 *(see WS 6.4)*
9. disastrous meltdown at this Russian power plant
10. part of atom where most of the mass can be found
11. two atoms of same element with different masses
13. discovered radium; coined the term "radioactive"
15. particle equivalent to an electron; emitted from unstable nuclei
17. radioactive gas found in some homes
18. if an oxygen loses a proton, it would become this
20. this happens on the sun
21. light amplification by stimulated emission of radiation *(hint- this is an acronym)*

Across

5. particle equivalent to a helium nucleus with very low penetration power
12. X-rays are a type of ________________ radiation
14. sub-atomic particle with a negative charge
16. sub-atomic particle with no charge
17. form of energy which travels in waves at the speed of light
19. a way to express how long it takes a radioactive material to decay
22. radioactive metal used in nuclear power plants
23. area of the nuclear plant where the chain reaction occurs
24. nuclear ___________ occurs in atomic weapons
25. a radioactive form of this element is used in dating ancient objects

Nuclear Radiation Shielding Lab Name: ____________________

Purpose: In **part 1**, you will measure background radiation using a digital Geiger counter. In **part 2** you will take radiation readings on an alpha (α), beta (β), and gamma (γ) source. You will attempt to block, or "shield" the radiations using air, paper, plastic, and lead. By comparing the measurements with no shield to measurements with a shield, you can determine which shields are most effective against various types of radiations.

Procedure: First we will measure background radiation, which is the amount of radiation naturally present.

1. Remove all radioactive material from vicinity of the counter.
2. Set the digital counter for 1 minute and record the number of counts per minute **(c.p.m.)** in the data table.
3. Repeat, and take the average of the 2 readings. This is your *average background radiation*.

Background Radiation

Reading 1	c.p.m.
Reading 2	c.p.m.
Average Background Radiation	c.p.m.

part 2: Now we will begin to measure our alpha (α), beta (β), and gamma (γ) sources.

α Alpha Readings (name of **alpha source**: ______________________________)

no shield (shelf 2)

air shield (shelf 6)	paper shield (shelf 2)	~~plastic shield (shelf 2)~~	lead shield (shelf 2)

β Beta Readings (name of **beta source**: ______________________________)

no shield (shelf 2)

air shield (shelf 6)	paper shield (shelf 2)	~~plastic shield (shelf 2)~~	lead shield (shelf 2)

γ Gamma Readings (name of **gamma source**: ______________________________)

no shield (shelf 2)

air shield (shelf 6)	paper shield (shelf 2)	~~plastic shield (shelf 2)~~	lead shield (shelf 2)

Questions: (more on side 2...)

1. What was your average background radiation? ____________
   Why were background radiation reading 1 & 2 not necessarily the same?

2. List several sources of background radiation:

3. Your measurement units are "**c.p.m.**", which stands for what? ______________________________

4. Compare the effects of the **air shield** on alpha, beta, & gamma by calculating the ratio (quotient) of "**air shield**" to "**no shield**" for each: (see example...)

no shield (shelf 2)	air shield (shelf 6)	paper shield (shelf 2)	plastic shield (shelf 2)	lead shield (shelf 2)
400	58	395	297	25

alpha ratio:

beta ratio:

gamma ratio:

• the **lowest** ratio is the **most** affected. Which is most affected? ____________________

---

5. Compare the effects of the **paper shield** on alpha, beta, & gamma by calculating the ratio (quotient) of "**paper shield**" to "**no shield**" for each: (see example...)

no shield (shelf 2)	air shield (shelf 6)	paper shield (shelf 2)	plastic shield (shelf 2)	lead shield (shelf 2)
400	58	395	297	25

alpha ratio:

beta ratio:

gamma ratio:

• the **lowest** ratio is the **most** affected. Which is most affected? ____________________

---

6. Compare the effects of the **plastic shield** on alpha, beta, & gamma by calculating the ratio (quotient) of "**plastic shield**" to "**no shield**" for each: (see example...)

no shield (shelf 2)	air shield (shelf 6)	paper shield (shelf 2)	plastic shield (shelf 2)	lead shield (shelf 2)
400	58	395	297	25

alpha ratio:

beta ratio:

gamma ratio:

no data

• the **lowest** ratio is the **most** affected. Which is most affected? ____________________

---

7. Compare the effects of the **lead shield** on alpha, beta, & gamma by calculating the ratio (quotient) of "**lead shield**" to "**no shield**" for each: (see example...)

no shield (shelf 2)	air shield (shelf 6)	paper shield (shelf 2)	plastic shield (shelf 2)	lead shield (shelf 2)
400	58	395	297	25

alpha ratio:

beta ratio:

gamma ratio:

• the **lowest** ratio is the **most** affected. Which is most affected? ____________________

---

8. Why do you think that **lead** is a better shield than **paper** or **plastic** in terms of blocking radiation?

9. Explain why smoke detectors, which contain radioactive americium, poses no health risk.

10. Nuclear reactor containment walls are lined with thick concrete, stainless steel, and sometimes even lead!! What type of radiation (**alpha**, **beta**, or **gamma**) do you suppose could be found inside which would warrant such extreme shielding measures?