

First Name: _____

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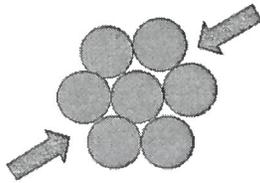
L09 – Worksheet – Radioactivity

/20 marks

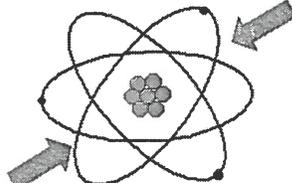
PART 1 – Fundamental Forces

Use the following information to answer Q1:

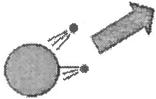
The Four Fundamental Forces



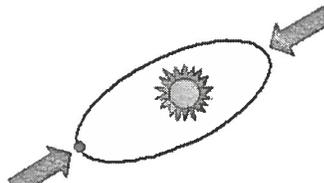
Binds the nucleus



Binds the atom



Causes radioactive beta decay



Binds the solar system

The Four Fundamental Forces

- 1 – Electromagnetic Force
- 2 – Gravitational Force
- 3 – Strong Nuclear Force
- 4 – Weak Nuclear Force

Q1: Use the Numerical Response numbers above to assign the fundamental force with its major contribution below.

3
Binds the nucleus

1
Binds the atom

4
Causes radioactive
Beta decay

2
Binds the solar
system

(Record your four digit answer in the Numerical Response boxes below)

3	1	4	2
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Use the following information to answer Q2-Q4:

Force	Associated Property	Effect	Range	Carrier Particle	Relative Strength
Gravitational	Mass	All masses attract each other	Infinite but weakens with distance	Graviton	10^{-36}
Electromagnetic	Electric charge	Opposites attract, likes repel	Infinite but weakens with distance	Photon	1
Strong	Color charge	Three colors combine to make neutral combinations	$\approx 10^{-15}$ meters (distance between protons in atomic nucleus)	Gluon	102
Weak	Weak charge	Massive particles decay to lower mass particles	$\approx 10^{-18}$ meters (1/1000 th proton diameter)	W & Z	10^{-7}

Q2: Which fundamental force has the smallest effective range?

- a. Gravitational
- b. Electromagnetic
- c. Strong
- d. Weak

Q3: Which fundamental force is the strongest?

- a. Gravitational
- b. Electromagnetic
- c. Strong
- d. Weak

Q4: Which fundamental force is the weakest?

- a. Gravitational
- b. Electromagnetic
- c. Strong
- d. Weak

■ KEY ■

Q5: Which fundamental force is suspected of being attractive, but repulsive at extremely close distances?

- a. Electromagnetic force
- b. Gravitational force
- c. Strong nuclear force**
- d. Weak nuclear force

KEEP IN MIND THAT SCIENTISTS ARE DIVIDED ON THIS STATEMENT. SOME THINK IT IS ONLY ATTRACTIVE.

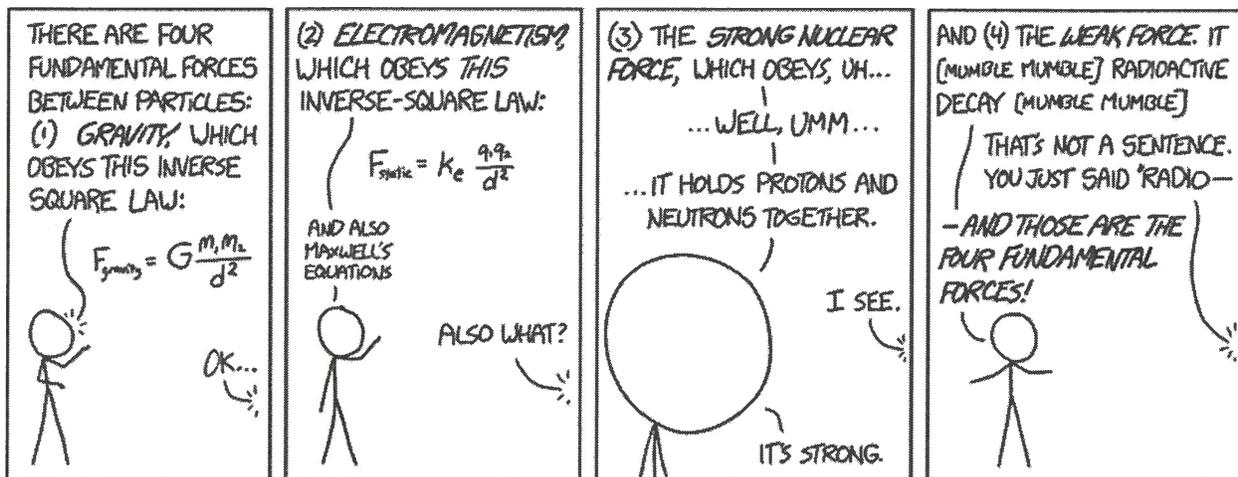
Q6: Which best describes the balance of attractive and repulsive forces acting inside the nucleus?

- a. $F_{\text{Strong}} + F_{\text{Gravity}} \geq F_{\text{Electromagnetic}}$**
- b. $F_{\text{Strong}} + F_{\text{Electrostatic}} \geq F_{\text{Gravity}}$
- c. $F_{\text{Gravity}} \geq F_{\text{Strong}} + F_{\text{Electromagnetic}}$
- d. $F_{\text{Strong}} \geq F_{\text{Electromagnetic}} + F_{\text{Gravity}}$

Gravity's contribution is negligible, but still attractive.

Question: How much do you actually need to know about these fundamental forces?

Answer:

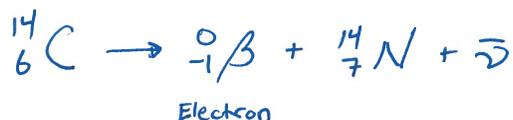


PART 2 – Alpha, Beta+, Beta-, and Gamma Decay

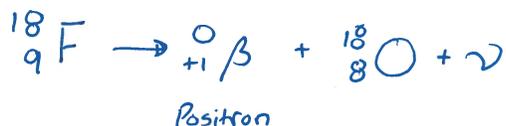
Q7: Uranium-238 decays via alpha decay. Write the equation.



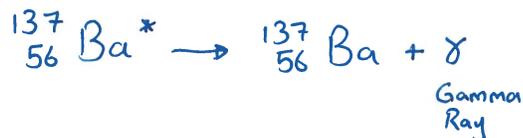
Q8: Carbon-14 decays via beta-negative decay. Write the equation.



Q9: Fluorine-18 decays via beta-positive decay. Write the equation.



Q10: Barium-137 decays via gamma decay. Write the equation.



Q11: The *Physics Principles* necessary to solve a radioactive decay question are:

(Record your **two digit** answer in the Numerical Response boxes below)

7	8		
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7- Conservation of Charge
8- Conservation of Nucleons

~~05~~

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PART 3 – Cloud Chambers and Magnetic Fields

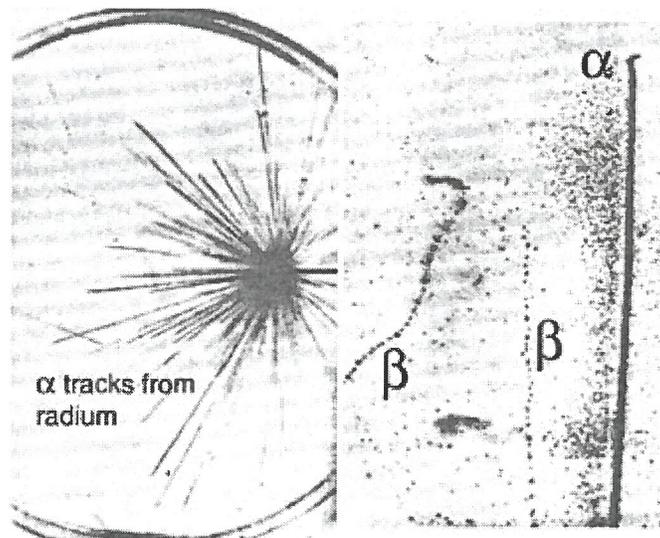
Use the following information to answer Q12:

Cloud Chambers

The cloud chamber, also known as the Wilson chamber, is a particle detector used for detecting ionizing radiation.

In its most basic form, a cloud chamber is a sealed environment containing a supersaturated vapor of water or alcohol. When a charged particle (for example, an alpha or beta particle) interacts with the mixture, the fluid is ionized. The resulting ions act as condensation nuclei, around which a mist will form (because the mixture is on the point of condensation).

The high energies of alpha and beta particles mean that a trail is left, due to many ions being produced along the path of the charged particle. These tracks have distinctive shapes (for example, an alpha particle's track is broad and shows more evidence of deflection by collisions, while an electron's is thinner and straight).



When any uniform magnetic field is applied across the cloud chamber, positively and negatively charged particles will curve in opposite directions, according to the Lorentz force law with two particles of opposite charge.

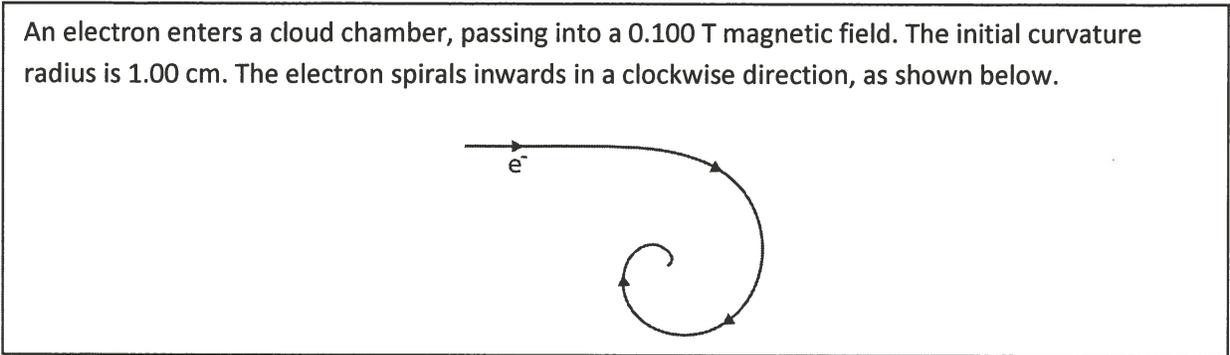
Q12: Which type of radiation will produce tracks in a cloud chamber?

- a. Alpha radiation only
- b. Beta radiation only
- c. Alpha and beta radiation only
- d. Alpha, beta, and gamma radiation

Gamma won't because it isn't a charged particle, it is EMR.

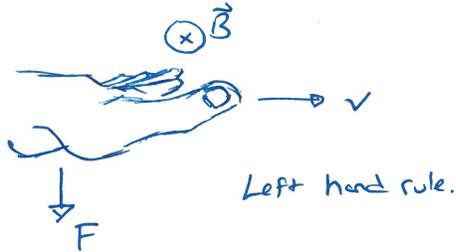
KEY

Use the following information to answer Q13-Q16:



Q13: What is the direction of the magnetic field?

- a. Into the page
- b. Out of the page
- c. Towards the top of the page
- d. Towards the bottom of the page



Q14: The electron entered the cloud chamber at an initial speed of $b \times 10^w$ m/s.

(Record your **three digit** answer in the Numerical Response boxes below)

1	.	7	6
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$$F_c = F_m$$

$$\frac{mv^2}{r} = qvB$$

$$\frac{mv}{r} = qB$$

$$v = \frac{qB|r}{m} = \frac{(1.60 \times 10^{-19})(0.1)(1 \times 10^{-2})}{(9.11 \times 10^{-31})}$$

Q15: What would the path of a positron, moving with an identical speed, look like?

- a. Same radius, spiraling clockwise.
- b. Same radius, spiraling counter-clockwise. *Some mass, opposite charge.*
- c. Larger radius, spiraling clockwise.
- d. Larger radius, spiraling counter-clockwise.

$$v = 1.7563 \times 10^8 \text{ m/s}$$

$$v \approx 1.76 \times 10^8 \text{ m/s}$$

Q16: Using a 2.00 T magnetic field, an electric field of strength $a.bc \times 10^d$ N/C must be used to get a velocity selector to select only particles which are moving at 100 m/s. The values of a , b , c , and d are , , , and .

(Record your **four digit** answer in the Numerical Response boxes below)

2	0	0	2
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$$q|E| = qv|B|$$

$$v = \frac{|E|}{|B|}$$

$$100 \text{ m/s} = \frac{|E|}{2.00 \text{ T}}$$

$$|E| = 200 \text{ N/C}$$

$$= 2.00 \times 10^2 \text{ N/C}$$

KEY

PART 4 – Half-Life Equations

Q17: A radioactive substance has a half-life of 30 minutes. What percentage of the atoms will *not* have decayed after 1 hour?

(Record your three digit answer in the Numerical Response boxes below)

2	5	.	0
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↑
Need to have three digits.

$$N = N_0 \left(\frac{1}{2}\right)^n$$

60 min ÷ 30 min per half-life = 2 half-lives.

$$N = 100 \left(\frac{1}{2}\right)^2$$

$$N = 25$$

So 25% remaining.

Q18: The half-life of Zn-71 is 2.4 minutes. If one had 100.0 grams at the beginning, how many grams would be left after 7.2 minutes have elapsed?

(Record your three digit answer in the Numerical Response boxes below)

1	2	.	5
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$$N = N_0 \left(\frac{1}{2}\right)^n$$

$$N = (100.0) \left(\frac{1}{2}\right)^{7.2 \div 2.4}$$

$$N = 100 \left(\frac{1}{2}\right)^3$$

$$N = (100)(0.125)$$

$$N = 12.5$$

Q19: Pd-100 has a half-life of 3.6 days. If one had 6.02×10^{23} atoms at the start, then $a.b \times 10^{cd}$ would be present after 20.0 days, where *a*, *b*, *c*, and *d* are __, __, __, and __.

(Record your four digit answer in the Numerical Response boxes below)

1	3	2	2
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$$N = N_0 \left(\frac{1}{2}\right)^n$$

$$N = (6.02 \times 10^{23}) \left(\frac{1}{2}\right)^{20 \div 3.6}$$

$$N = (6.02 \times 10^{23}) \left(\frac{1}{2}\right)^{5.5}$$

$$N = 1.279 \times 10^{22}$$

$$N \approx 1.3 \times 10^{22} \text{ atoms}$$

Q20: Fermium-253 has a half-life of 0.334 seconds. A radioactive sample is considered to be complete decayed after 10 half-lives. How much time will elapse for this sample to be considered gone?

(Record your three digit answer in the Numerical Response boxes below)

3	.	3	4
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Each half-life is 0.334 seconds.

10 half-lives? $10 \times 0.334 = 3.34$ seconds