IB Physics
27.2 Group Quiz

Name____________________________

Show your work, and circle your answers and use sig figs to receive full credit.

Closest Approach: $E_k = {}^1/_2 mv^2$ $E_p = qV_e = \frac{kQq}{r}$ **Q = 2e, q = Ze 1 fm = 10^{-15} m**

1. An alpha particle (m = $6.64\text{x}10^{-27}$ kg) going $5.36\text{x}10^{7}$ m/s will get how close to a lead (Z = 82) nucleus if it hits head on? (3.97 fm)

2. A speeding alpha particle (m = $6.64\text{x}10^{-27}$ kg) hits a cobalt (Z = 27) nucleus head on. If it comes within 56.0 fm of the nucleus' center, how fast was it going to start with? ($8.19\text{x}10^{6}$ m/s)

3. A 36.0 MeV alpha particle (m = $6.64\text{x}10^{-27}$ kg) can get how close to a gold nucleus (Z = 79)? (36.0 MeV is the KE) (6.32 fm)

Bohr Atom: $\lambda = \frac{hc}{E}$ **and** $E = -\frac{13.6}{n^2} eV$

4. What is the wavelength of the photon associated with an electron transition from n = 2 to n = 1 in a hydrogen atom? Is the photon being absorbed, or emitted? (122 nm – emitted)

5. What is the wavelength of the photon associated with an electron transition from n = 2 to n = 5 in a hydrogen atom? Is the photon being absorbed, or emitted? (434 nm – absorbed)

Nuclear Radius: $R = R_0 A^{\frac{1}{3}}$ **R_o = 1.2 x 10^{-15} m (1.2 fm)**

6. What is the radius of Cl-36 nucleus? (3.96 fm)

7. What is the likely mass number of a nucleus with a radius of $7.064\text{x}10^{-15}$ m? (204)

Heisenberg Indeterminacy: $\Delta x \Delta p \geq \frac{h}{4\pi}$ **or** $\Delta E \Delta t \geq \frac{h}{4\pi}$

8. To effect an alpha decay, an alpha particle must "borrow" 23.0 MeV of energy. What time does it have to escape? (1.43×10^{-23} s)

9. A proton has an uncertainty in its velocity of $\pm1.20\times10^{6}$ m/s. What is the minimum uncertainty in its position? (13.1 fm)

Conceptual Questions:

I: How was Rutherford's atomic model different from Thomson's "plum pudding" model?

I: How did Rutherford discover the nucleus? What size did he determine for the atom and the nucleus?

I1: How does the density of a nucleus change with mass number? What is the density of the Uranium-235 nucleus? What is the density of the carbon-12 nucleus? Calculate both densities: (2.3×10^{17} kg m^{-3})
$m = A(1.661\times10^{-27}\text{ kg})$, $V = {}^{4}/_{3}\pi r^3$, $\rho = {}^{m}/_{V}$

K: Specifically what phenomenon, what observed behavior of atoms was Bohr trying to explain with his quantum atomic model?

N: Energy indeterminacy accounts for nuclear decay - particles in the nucleus "borrow" energy to escape - Where does the energy come from that they "borrow", and where does it go after it has escaped?

O: What was the Einstein-Bohr debate about? What did Einstein object to in quantum mechanics?

Part A: Find the missing decay product:

1	$\tau^- \rightarrow \pi^- + \pi^o + ??$ υ_τ	$?? \rightarrow \pi^+ + \pi^o + \overline{\upsilon_\tau}$ τ^+	$\tau^- \rightarrow \upsilon_\tau + ?? + \overline{\upsilon_e}$ e^-	$\tau^+ \rightarrow \overline{\upsilon_\tau} + e^+ + ??$ υ_e
2	$\tau^- \rightarrow ?? + \mu^- + \overline{\upsilon_\mu}$ υ_τ	$\tau^+ \rightarrow ?? + \mu^+ + \upsilon_\mu$ $\overline{\upsilon_\tau}$	$?? \rightarrow e^- + \overline{\upsilon_e} + \upsilon_\mu$ μ^-	$\mu^+ \rightarrow e^+ + ?? + \overline{\upsilon_\mu}$ υ_e
3	$\mu^- \rightarrow e^- + \overline{\upsilon_e} + \upsilon_\mu + e^+ + ??$ e^-	$\mu^+ \rightarrow e^+ + ?? + \overline{\upsilon_\mu} + e^+ + e^-$ υ_e	$K_L^o \rightarrow \pi^+ + ?? + \overline{\upsilon_\mu}$ μ^-	$K^+ \rightarrow ?? + \upsilon_\mu$ μ^+

Part B: For these reactions, indicate if it is possible, or indicate <u>every</u> law it violates:

1	$p + n \rightarrow K^+ + \eta^o + \Xi^o$ No, baryon number, Strangeness	$p + n \rightarrow p + \bar{p} + \bar{n}$ No, charge and baryon number	$n + n \rightarrow \Lambda^o + \Sigma^o$ No, Strangeness	$n + n \rightarrow \Omega^+ + \Omega^-$ No, baryon number
2	$p + p \rightarrow \Omega^+ + e^+ + \Lambda^o + \Sigma^o + n$ No, Le, Strangeness	$p + p \rightarrow p + n + n + \Omega^+$ No, Strangeness	$p + p \rightarrow \tau^+ + \upsilon_\tau + \mu^+ + \overline{\upsilon_\mu}$ No, Baryon and Lμ	$p + n \rightarrow n + n + \tau^+ + \upsilon_\tau$ Yes
3	$p + \bar{p} \rightarrow \tau^- + \Lambda^o + \Omega^+ + \overline{\upsilon_\tau}$ No, Strangeness	$p + \bar{n} \rightarrow \tau^+ + \tau^-$ No, charge	$\bar{n} + n \rightarrow \tau^+ + \tau^-$ Yes	$p + \bar{p} \rightarrow \Sigma^- + \Omega^+$ No, Strangeness
4	$p + p \rightarrow p + p + \pi^o$ yes	$p + p \rightarrow p + n + \pi^+$ yes	$n + n \rightarrow \Xi^+ + \overline{\Lambda^o} + \Omega^- + n + n + n$ yes	$\pi^- + p \rightarrow \pi^o + n + \pi^- + \pi^+$ yes

Part C: Write the quark combinations that make up a proton and a neutron: p =__________ n =__________
Identify the following quark combinations as either a meson, or a baryon. Determine the baryon number, strangeness, and the charge of each:

		Baryon or Meson?	B = ?	S = ?	q = ?
1	$s\bar{s}$	M	0	0	0
2	dsc	B	+1	-1	0
3	$\bar{u}\bar{u}\bar{u}$	B	-1	0	-2
4	$s\bar{u}$	M	0	-1	-1
5	$d\bar{s}$	M	0	+1	0
6	sss	B	+1	-3	-1
7	$\bar{u}\bar{u}\bar{c}$	B	-1	0	-2
8	$u\bar{s}$	M	0	+1	+1
9	$c\bar{d}$	M	0	0	+1
10	$\bar{s}\bar{s}\bar{c}$	B	-1	+2	0
11	ucc	B	+1	0	+2
12	$s\bar{b}$	M	0	-1	0

Charge	Quarks			Baryon number
$\frac{2}{3}e$	u	c	t	$\frac{1}{3}$
$-\frac{1}{3}e$	d	s	b	$\frac{1}{3}$

All quarks have a strangeness number of 0 except the strange quark that has a strangeness number of −1

Data Packet reference for decays:

Charge	Leptons		
−1	e	μ	τ
0	υ_e	υ_μ	υ_τ

All leptons have a lepton number of 1 and antileptons have a lepton number of −1