Key

First Name:_____ Last Name:_____

## L07 – Worksheet – Radioactive Decay

Atomic Number Z
Neutron Number N
Atomic Mass Number A

$^{A}_{Z}X$

$A = Z + N$

$^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}\beta + \bar{\nu}$ $(n^0 \rightarrow p^+)$

$^{A}_{Z}X \rightarrow {}^{A}_{Z-1}Y + {}^{0}_{1}\beta + \nu$ $(p^+ \rightarrow n^0)$

$^{A}_{Z}X^* \rightarrow {}^{A}_{Z}X + \gamma$ (excited → lower energy)

Alpha ($\alpha$): Helium nucleus
Beta ($\beta$): High energy electron
Gamma ($\gamma$): High energy photon

### Textbook Questions

**Pg 791 #1:** How many neutrons are in a nucleus of $^{24}_{12}Mg$?

$^{24}_{12}Mg$ $\quad 24 - 12 = 12$

**Pg 791 #2:** Find the atomic mass number for a uranium atom that contains 92 protons and 146 neutrons.

$A = Z + N$
$= 92 + 146$
$= 238$

**Pg 799 #1-3:** Determine whether these decay processes are possible.

**Pg 799 #1:** $^{212}_{84}Po \rightarrow {}^{210}_{86}Rn + {}^{4}_{2}\alpha$

Impossible. $210 + 4 \neq 212$
$86 + 2 \neq 84$

**Pg 799 #2:** $^{233}_{91}Pa \rightarrow {}^{233}_{92}U + {}^{0}_{-1}\beta$

Possible. $233 + 0 = 233$
$92 + -1 = 91$

**Pg 799 #3:** $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{1}_{1}H$

Impossible. $14 + 1 \neq 14$
$7 + 1 \neq 6$

KEY

**Pg 800 #1-3:** Write the α-decay process for these elements, and name the parent and daughter elements.

**Pg 800 #1:** $^{230}_{90}Th$

$^{230}_{90}Th \rightarrow {}^{226}_{88}Ra + {}^{4}_{2}\alpha$

PARENT DAUGHTER

**Pg 800 #2:** $^{238}_{92}U$

$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}\alpha$

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**Pg 800 #3:** $^{214}_{84}Po$

$^{214}_{84}Po \rightarrow {}^{210}_{82}Pb + {}^{4}_{2}\alpha$

**Pg 803 #1:** Find the element produced by $\beta^-$ decay of

a. $^{228}_{88}Ra$

(A) $^{228}_{88}Ra \rightarrow {}^{228}_{89}Ac + {}^{0}_{-1}\beta + \bar{\nu}$

b. $^{212}_{82}Pb$

(B) $^{212}_{82}Pb \rightarrow {}^{212}_{83}Bi + {}^{0}_{-1}\beta + \bar{\nu}$

**Pg 805 #1ab:** (a) What isotope will $\beta^+$ decay of thallium-202 produce? (b) Write the process for this decay.

(A) $^{202}_{81}Tl \rightarrow {}^{202}_{80}Hg + {}^{0}_{1}\beta + \nu$

(B) See above.

**Pg 810 #4:** (a) Which type of beta decay transmutes carbon-14 into nitrogen? (b) Write the process for this decay.

(A) $^{14}_{6}C \rightarrow {}^{14}_{7}N + {}^{0}_{-1}\beta + \bar{\nu}$ Beta ($\beta^-$) decay.

(B) See above.

KEY

**Pg 810 #5:** (a) Which type of beta decay transmutes the sodium isotope $^{22}_{11}Na$ into $^{22}_{10}Ne$? (b) Write the process for this decay.

(A) $^{22}_{11}Na \longrightarrow {}^{22}_{10}Ne + {}^{0}_{1}\beta + \nu$ Beta ($\beta^+$) decay.

(B) See above.

**Pg 810 #11:** Identify each type of decay in this series, and name the parent and daughter elements.

(a) $^{232}_{90}Th \rightarrow {}^{228}_{88}Ra^* + {}^{4}_{2}\propto$

(b) $^{22}_{11}Na \rightarrow {}^{22}_{10}Ne + {}^{0}_{1}\beta + \nu$

(c) $^{228}_{88}Ra^* \rightarrow {}^{228}_{88}Ra + \gamma$

(d) $^{228}_{88}Ra \rightarrow {}^{228}_{89}Ac + {}^{0}_{-1}\beta + \bar{\nu}$

(e) $^{228}_{89}Ac \rightarrow {}^{228}_{90}Th + {}^{0}_{-1}\beta + \bar{\nu}$

(f) $^{228}_{90}Th \rightarrow {}^{224}_{88}Ra + {}^{4}_{2}\alpha$

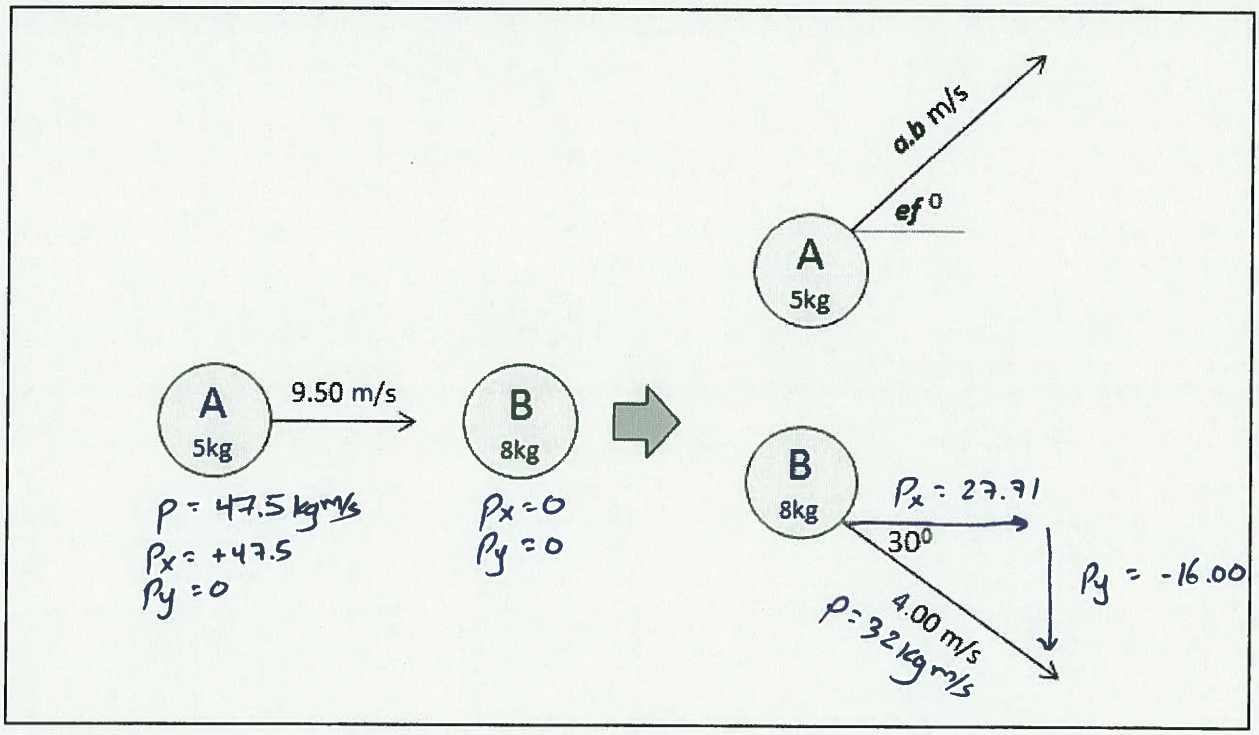
(g) $^{0}_{1}p \rightarrow {}^{0}_{0}n + {}^{0}_{1}\beta + \nu$

| | | PARENT: | DAUGHTER: |
|---|---|---|---|
| (A) | Alpha | THORIUM | RADIUM |
| (B) | $\beta^+$ | SODIUM | NEON |
| (C) | Gamma | RADIUM | RADIUM |
| (D) | $\beta^-$ | RADIUM | ACTINIUM |
| (E) | $\beta^-$ | ACTINIUM | THORIUM |
| (F) | Alpha | THORIUM | RADIUM |
| (G) | $\beta^+$ | PROTON | NEUTRON |

KEY

## Cumulative Review

*Use the following information to answer Q1:*




**Q1:** Object *A* rebounds with a velocity of ***a.b*** m/s [***ef*** $^0$], where ***a, b, e,*** and ***f*** are ___, ___, ___, and ___.

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

| 5 | 1 | 3 | 9 |
|---|---|---|---|

x-comp

$P_i = P_f$

$(47.5) + (0) = (27.71) + P_{Af_x}$

$P_{Af_x} = +19.79$

y-comp

$P_i = P_f$

$(0) + (0) = (-16) + P_{Af_y}$

$P_{Af_y} = +16$

$V_f = 5.089$ m/s

$P_f = 25.449$

38.955

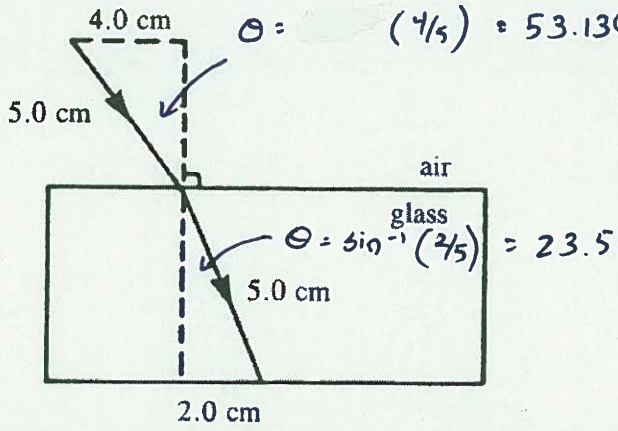
16

19.29

$V_f = 5.1$ m/s [39°]

KEY

*Use the following information to answer Q2:*




$\theta = \sin^{-1}(4/5) = 53.130°$

$n_1 = 1.00$
$v_1 = 3.0\times10^8$
$\theta_1 = 53.130$

$\theta = \sin^{-1}(2/5) = 23.578°$

$n_2 = ?$
$v_2 = ?$
$\theta_2 = 23.578$

A ray of light travels from air into glass.

**Q2:** The speed of light in the glass is

a) $1.5 \times 10^8$ m/s
b. $2.0 \times 10^8$ m/s
c. $2.3 \times 10^8$ m/s
d. $2.6 \times 10^8$ m/s

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2}$$

$$\frac{\sin 53.130}{\sin 23.578} = \frac{3.0\times10^8}{v_2}$$

$$v_2 = 1.50\times10^8 \text{ m/s}$$

**Q3:** An incident photon of wavelength 450nm is incident on a Sodium surface with a work function of 2.28eV. Determine the kinetic energy of the emitted electrons, measured in electronvolts.

*(Record you **three-digit** answer in the numerical response boxes below.)*

| 0 | . | 4 | 8 |
|---|---|---|---|

$E_{photon} \rightarrow W + E_K$

$$\frac{hc}{\lambda} \rightarrow W + E_K$$

$$\frac{(4.14\times10^{-15})(3.0\times10^8)}{(450\times10^{-9})} \rightarrow 2.28 + E_K$$

$$2.76 \rightarrow 2.28 + E_K$$

$$E_K = 0.48 \text{ eV}$$

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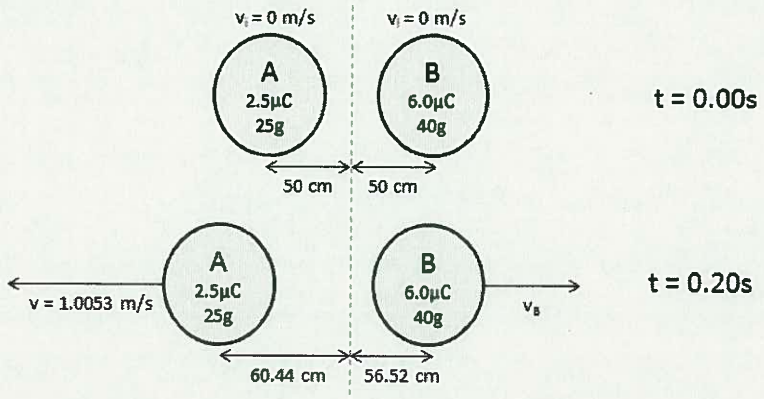
*Use the following information to answer Q4-Q7:*

Two positively charged spheres are held 1.00m apart. Once released, both charges electrostatically repel from each other, per the diagram below.




**Q4:** The instantaneous acceleration of *Object A*, the moment it is released, is

a. $5.39 \times 10^{-3}$ m/s$^2$
b. $2.16 \times 10^{-2}$ m/s$^2$
c. 5.39 m/s$^2$
d. $2.16 \times 10^{1}$ m/s$^2$

$F_e = \frac{kq_1q_2}{r^2} = \frac{(8.99\times10^9)(2.5\times10^{-6})(6.0\times10^{-6})}{(1.0)^2}$

$F_e = 0.13485\ N$

$a = \frac{F_{net}}{m} = \frac{0.13485}{25\times10^{-3}} = 5.394\ m/s^2$

**Q5:** What is the impulse experienced by *Object A* within the first 0.20 seconds?

a. $2.35 \times 10^{-2}$ Ns
b. $2.51 \times 10^{-2}$ Ns
c. $2.70 \times 10^{-2}$ Ns
d. $2.87 \times 10^{-2}$ Ns

$\vec{F}at = m\Delta\vec{v}$

Force isn't constant, so look at $m\Delta\vec{v}$ part.

$Fat = m\Delta\vec{v}$
$= (25\times10^{-3})(1.0053 - 0)$
$= 0.0251325$ Ns
$\approx 2.51\times10^{-2}$ Ns

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**Q6:** What is the speed of *Object B* at exactly 0.20 seconds is ***a.bc*** x $10^{-d}$ m/s, where ***a, b, c,*** and ***d*** are ___, ___, ___, and ___.

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

| 6 | 2 | 8 | 1 |
|---|---|---|---|

$$P_i = P_f$$

$$(0)+(0) = (25\times10^{-3})(-1.0053) + (40\times10^{-3})(v_f)$$

$$v_f = 0.6283125 \text{ m/s}$$

$$\approx 6.28\times10^{-1} \text{ m/s}$$

**Q7:** The electrostatic force between *Object A* and *Object B*, measured at exactly 0.20s, is ***a.bc*** x $10^{-d}$ N, where ***a, b, c,*** and ***d*** are ___, ___, ___, and ___.

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

| 9 | 8 | 6 | 2 |
|---|---|---|---|

$$F_e = \frac{kq_1q_2}{r^2} = \frac{(8.99\times10^{9})(2.5\times10^{-6})(6.0\times10^{-6})}{(1.1696)^2}$$

$$F_e = 9.86\times10^{-2} \text{ N}$$