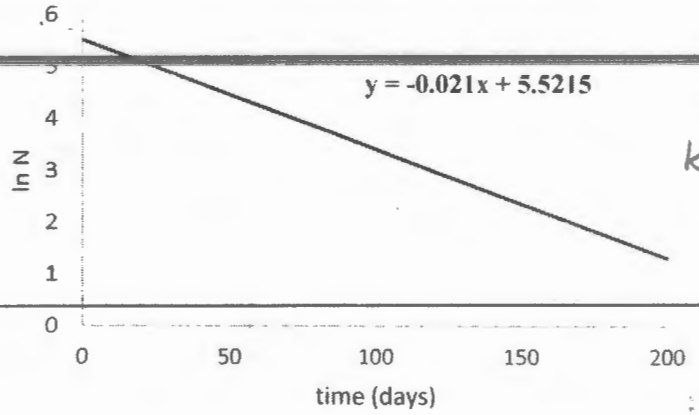
Name: _____ date: _____ period: _____

ch. 25 & 17 nuclear chem & kinetics test 55 points honors chem istry

In problems involving any calculation, show your work in an organized manner, include (i) any relevant equation (or formula), (ii) conversion factor(s), (iii) put the proper units in your calculations and answer, and (iv) proper number of significant figures in your answer.

1. Based on the below hypothetical experimental data of the decay of a radioactive isotope



what is it's half-life ? [10 points]

$k = -\text{slope} = -(-0.021\ \text{days}^{-1}) = 0.021\ \text{days}^{-1}$ — 2 pt, 3

$\ln 2 = t_{\frac{1}{2}} k$ — 2, 3

$t_{\frac{1}{2}} = \frac{\ln 2}{k} = \frac{\ln 2}{(0.021\ \text{days}^{-1})} = 33\ \text{days}$

2. 125 mg of a hypothetical radioactive isotope has a half-life of 785 years. The sample currently has 37 mg of the hypothetical radioactive isotope; what is the age of the sample ? [10 points]

2 pt. 3 i) $\ln 2 = k\, t_{\frac{1}{2}}$

$k = \frac{\ln 2}{t_{\frac{1}{2}}} = \frac{\ln 2}{785\ \text{years}} = 8.83 \cdot 10^{-4}\ \text{/years}$

2 3 ii) $t = \frac{\ln\left(\frac{N_0}{N}\right)}{k} = \frac{\ln\left(\frac{125}{37}\right)}{(8.83 \cdot 10^{-4}\ \text{/years})} = 1379\ \text{years}$

rate = k $[C_4H_{10}]^x [O_2]^y$

3. In the reaction: $C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$, what is the rate law of the reaction (include the numeric value and units of the rate constant) based on the below hypothetical experimental data. [15 points]

ecpt	$[C_4H_{10}]$; mM	$[O_2]$; mM	Initial rate (mM / sec)
1	1.0	1.0	5.0
2	4.0	1.0	20
3	2.0	2.0	40

i) $\frac{r_2}{r_1} = \frac{20\ mM/s}{5\ mM/s} = 4^x$ 1pt

$4 = 4^x$

$x = 1$

ii) $\frac{r_3}{r_1} = \frac{40\ mM/s}{5\ mM/s} = 2^x 2^y$ 4

$8 = 2^x 2^y$

$4 = 2^y$; $y = 2$

iii) $r_1 = \frac{5\ mM}{s} = k\,(1\ mM)(1\ mM)^2$ 4

$k = \frac{5}{mM^2 s}$

3 pts

(iv) rate = $\frac{5}{mM^2 s}[C_4H_{10}][O_2]^2$ or $\frac{5 \cdot 10^3}{M^2 s}[C_4H_{10}][O_2]^2$

4. What is the activation energy of a reaction, where it's rate doubles when the temperature increases from 20 °C to 40 °C. [10 points]

$k = A e^{-E_a/RT}$

$\frac{k_1}{k_2} = e^{-\frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)}$ 3pt

293 → 313 K

$K_2 \rightarrow K_1$ 2pt

$\ln\left(\frac{k_1}{k_2}\right) = -\frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$

$\ln 2 = -\frac{E_a}{8.314\ J/mol\,K}\left(\frac{1}{313} - \frac{1}{293}\right)$ 3pt

$\ln 2 = 2.6 \cdot 10^{-5} E_a \rightarrow E_a = 26.7\ kJ/mol$ 2pt

5. In the reaction: A → B, it takes 25 minutes for 25 mg A to become 15 mg A; what is the half life of the reaction. Assume that the reaction is a first order reaction. [10 points]

i) $k = \frac{\ln(N_0/N)}{t} = \frac{\ln(25\ mg/15\ mg)}{25\ min} = 0.0204\ /min$ 2+3 pt @

ii) $\ln 2 = k \cdot t_{1/2}$

$t_{1/2} = \frac{\ln 2}{k} = \frac{\ln 2}{0.0204/min} = 34\ min$

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ch. 25 & 17 nuclear chem & kinetics **retest** 55 points (5 ec) honors chemistry

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1. Fill-in the below blank about (hypothetical ?) nuclear reactions. [5 points]

a. alpha decay of ^{46}Ca: $^{46}_{20}Ca \rightarrow {}^{4}_{2}He + {}^{42}_{18}Ar$

b. beta (minus) decay of ^{46}Ca: $^{46}_{20}Ca \rightarrow {}^{0}_{-1}e + {}^{46}_{21}Sc$

c. positron (minus) decay of ^{46}Ca: $^{46}_{20}Ca \rightarrow {}^{0}_{1}e + {}^{46}_{19}K$

d. $^{2}_{1}H + {}^{25}_{12}Mg \rightarrow {}^{27}_{13}Al$ and it's a (n) fusion type of nuclear reaction

e. $^{2}_{1}H + {}^{25}_{12}Mg \rightarrow {}^{16}_{9}F + {}^{11}_{4}Be$ and it's a (n) transmutation type of nuclear reaction

2. A hypothetical radioactive isotope has a half-life of 825 years and there is currently 100.0 mmole of the radioactive isotope and 25.0 mmole of the nonradioactive product in the sample Assuming that there was no nonradioactive isotope in the sample originally, what is the age of the sample ? [15 points]

i) $k\,t_{\frac{1}{2}} = \ln 2$

$k\ 825\ \text{years} = \ln 2$

$k = 0.00084\ \frac{}{\text{year}}$

ii) $A^* \longrightarrow A$

t=0	125	(0)
Δ	-25	+25
now	(100)	(25)

iii) $t = \frac{\ln\left(\frac{A_0}{A}\right)}{k} = \frac{\ln\left(\frac{125}{100}\right)}{\left(0.00084\ \frac{}{\text{years}}\right)} = 266.\ \text{years}$

3. Based on the below hypothetical reaction mechanism, [5 points; weekly quiz problem]

$A + B \rightleftarrows AB$ rate constants; k1 & k-1

$AB + B \rightarrow AB_2$ rate constant; k2; [slowest step]

a. What is the reaction described by this mechanism ?

$A + 2B \rightarrow AB_2$

b. What is the rate law of the reaction ?

i) rate $= k_2[AB][B]$ – step 2 (1)

ii) $r_f = r_b$ – step 1

$k_1[A][B] = k_{-1}[AB]$

$[AB] = \frac{k_1}{k_{-1}}[A][B]$ (2)

iii) subst (2) into (1)

rate $= \frac{k_1 k_2}{k_{-1}}[A][B]^2$

4. Determine the exponents in the rate law for the reaction [10 points; weekly quiz problem]

$$Na_2S_2O_3\,(aq) + HCl\,(aq) \rightarrow S\,(s) + SO_2\,(g) + H_2O\,(l) + NaCl\,(aq)$$

a. design an experiment; basis / rationale ? hint: the "end of the reaction" is when the clear solution becomes cloudy due to the formation of sulfur

i) $\frac{\left(\frac{\Delta s}{\Delta t_2}\right)}{\left(\frac{\Delta s}{\Delta t_1}\right)} = \frac{\Delta t_2}{\Delta t_1} = \left(\frac{[Na_2S_2O_3]_2}{[Na_2S_2O_3]_1}\right)^x \left(\frac{[HCl]_2}{[HCl]_1}\right)^y$

ii) rate

iii)

expt	time	$[Na_2S_2O_3]$	$[HCl]$
1			
2			0 = same
3			

b. describe the calculations; basis / rationale ?

5. In the reaction: $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$, what is ___ ? [10 points]

a. rate of the reaction if carbon dioxide gas appears at a rate of 10.0 mmol / sec ?

$$\text{rate} = \frac{1}{4}\frac{\Delta [CO_2]}{\Delta t}$$

$$= \frac{1}{4}\ 10\ \frac{\text{mmol}}{\text{sec}}$$

$$= 2.5\ \text{mmol/sec}$$

2 + 3 pts @

b. rate the appearance of water if oxygen gas disappears at a rate of 35 mmol / sec ?

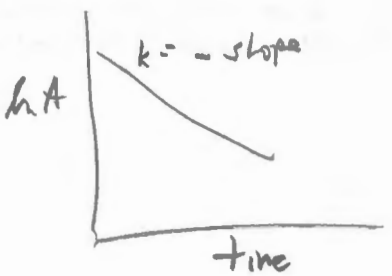
$$\frac{1}{6}\frac{\Delta [H_2O]}{\Delta t} = -\frac{1}{7}\frac{\Delta [O_2]}{\Delta t}$$

$$\frac{\Delta [H_2O]}{\Delta t} = -\frac{6}{7}\frac{\Delta [O_2]}{\Delta t} = -\frac{6}{7}\left(-35\ \frac{\text{mmol}}{\text{sec}}\right) = +30\ \frac{\text{mmol}}{\text{sec}}$$

6. In a hypothetical reaction: A → B, describe how to differentiate between a zero, first, and second order reaction using graphical analysis ? Write the corresponding rate law and describe how to find the value of the rate constant & what is it's units ? [15 points]

i) 1st order

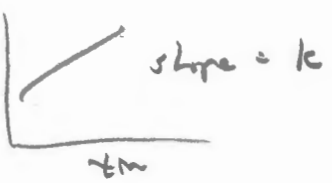
$r = k[A]$



5 pts @

ii) 2nd order

$r = k[A]^2$



iii) 0th order

$r = k$