

This print-out should have 18 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001 4.0 points

The rate of formation of $\text{NO}_2(\text{g})$ in the reaction



is $5.78 \text{ (mol NO}_2\text{)/L/s}$. What is the rate at which N_2O_5 decomposes?

1. $5.78 \text{ (mol N}_2\text{O}_5\text{)/L/s}$
2. $2.89 \text{ (mol N}_2\text{O}_5\text{)/L/s}$ **correct**
3. $0.723 \text{ (mol N}_2\text{O}_5\text{)/L/s}$
4. $11.6 \text{ (mol N}_2\text{O}_5\text{)/L/s}$
5. $1.45 \text{ (mol N}_2\text{O}_5\text{)/L/s}$

Explanation:

002 4.0 points

Which naturally occurring type of radiation has the greatest penetrating power?

1. alpha
2. neutron
3. gamma **correct**
4. beta

Explanation:

Gamma can penetrate thin lead sheets or a few inches of concrete; alpha and beta cannot. Neutrons are not emitted via natural radioactive decay.

003 4.0 points

One Becquerel is equal to ____ and one Curie is equal to ____.

1. one Neutron emission per second; 1 disintegration per second

2. 60 disintegrations per second; one beta particle emission per second

3. one Neutron emission per second; 60 disintegrations per second

4. one alpha particle emission per second; one beta particle emission per second

5. 1 disintegration per second; 3.7×10^{10} disintegrations per second **correct**

6. one Curie; one Neutron emission per second

7. one Curie; 3.7×10^{10} disintegrations per second

8. one Curie; one beta particle emission per second

Explanation:

1 Becquerel = 1 disintegration per second and one Curie = 3.7×10^{10} disintegrations per second.

004 4.0 points

A sample of carbon from the Lascaux cave in France contained 12% of the original fraction carbon-14. Estimate the age of this sample. The half-life of carbon-14 is 5.73×10^3 year.

1. 100,000 years
2. 50,000 years
3. 25,000 years
4. 17,500 years **correct**
5. 75,000 years

Explanation:

005 4.0 points

The overall reaction:



has an empirically determined rate law with a single bimolecular collision that doesn't in-

volve CO. If $k = 2.0 \times 10^2 \text{ M}^{-1} \cdot \text{s}^{-1}$, $[\text{NO}_2] = 0.3 \text{ M}$ and $[\text{CO}] = 0.1 \text{ M}$, what is the observed rate?

1. $6 \text{ M} \cdot \text{s}^{-1}$

2. $60 \text{ M} \cdot \text{s}^{-1}$

3. $1.8 \text{ M} \cdot \text{s}^{-1}$

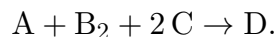
4. $18 \text{ M} \cdot \text{s}^{-1}$ **correct**

Explanation:

$$\begin{aligned} \text{rate} &= k \cdot [\text{NO}_2]^2 \\ &= 2.0 \times 10^2 \text{ M}^{-1} \cdot \text{s}^{-1} \cdot [0.3]^2 \\ &= 1.8 \text{ M} \cdot \text{s}^{-1} \end{aligned}$$

006 4.0 points

The following data were collected for the net reaction



	Initial [A] M	Initial [B ₂] M	Initial [C] M	Initial rate M/s
1	0.01	0.01	0.10	1.20×10^3
2	0.02	0.01	0.10	4.80×10^3
3	0.03	0.01	0.20	2.16×10^4
4	0.04	0.02	0.10	3.84×10^4

Which of the following is the rate law for this reaction? (Note that the units for the rate constant are omitted in the following answers.)

1. $\text{Rate} = (1.2 \times 10^{11}) [\text{A}]^2 [\text{B}_2]^2$

2. $\text{Rate} = (1.2 \times 10^9) [\text{A}] [\text{B}_2]^2$

3. $\text{Rate} = (1.2 \times 10^{10}) [\text{A}]^2 [\text{B}_2] [\text{C}]$ **correct**

4. $\text{Rate} = (1.2 \times 10^{10}) [\text{A}] [\text{B}_2]^2$

5. $\text{Rate} = (1.2 \times 10^{12}) [\text{A}]^2 [\text{B}_2] [\text{C}]$

6. $\text{Rate} = (1.2 \times 10^6) [\text{B}_2] [\text{C}]$

Explanation:

Compare rates of two experimental runs such chosen such that only one unknown order appears. This enables you to find the value of one order. Repeat for the other two orders. There may be more than one way to do this. For example:

$$\text{Rate} = k [\text{A}]^x [\text{B}_2]^y [\text{C}]^z$$

$$\begin{aligned} \frac{\text{Rate}_3}{\text{Rate}_1} &= \frac{k [\text{A}]_3^2 [\text{B}_2]_3^1 [\text{C}]_3^2}{k [\text{A}]_1^2 [\text{B}_2]_1^1 [\text{C}]_1^2} \\ \frac{2.16 \times 10^4}{1.20 \times 10^3} &= \left(\frac{0.03}{0.01} \right)^2 \left(\frac{0.01}{0.01} \right) \left(\frac{0.20}{0.10} \right)^z \\ 18 &= 9 \cdot 2^z \\ 2 &= 2^z \\ z &= 1 \end{aligned}$$

$$\begin{aligned} \frac{\text{Rate}_4}{\text{Rate}_1} &= \frac{k [\text{A}]_4^2 [\text{B}_2]_4^y [\text{C}]_4^1}{k [\text{A}]_1^2 [\text{B}_2]_1^y [\text{C}]_1^1} \\ \frac{3.84 \times 10^4}{1.20 \times 10^3} &= \left(\frac{0.04}{0.01} \right)^2 \left(\frac{0.02}{0.01} \right)^y \left(\frac{0.10}{0.10} \right)^1 \\ 32 &= 16 \cdot 2^y \\ 2 &= 2^y \\ y &= 1 \end{aligned}$$

$$\begin{aligned} \frac{\text{Rate}_2}{\text{Rate}_1} &= \frac{k [\text{A}]_2^2 [\text{B}_2]_2^1 [\text{C}]_2^1}{k [\text{A}]_1^2 [\text{B}_2]_1^1 [\text{C}]_1^1} \\ \frac{4.80 \times 10^3}{1.20 \times 10^3} &= \left(\frac{0.02}{0.01} \right)^2 \left(\frac{0.01}{0.01} \right)^1 \left(\frac{0.10}{0.10} \right)^1 \\ 4 &= 2^y \\ y &= 2 \end{aligned}$$

$$\begin{aligned} k &= \frac{\text{Rate}}{[\text{A}]^2 [\text{B}_2] [\text{C}]} \\ &= \frac{1.20 \times 10^3 \text{ M} \cdot \text{s}^{-1}}{(0.01)^2 (0.01) (0.1) \text{ M}^4} \\ &= 1.20 \times 10^{10} \text{ M}^{-3} \cdot \text{s}^{-1} \end{aligned}$$

$$\text{Rate} = (1.2 \times 10^{10}) [\text{A}]^2 [\text{B}_2] [\text{C}]$$

007 4.0 points

Consider the elementary reaction:



If $k = 1.03 \times 10^{-2} \text{ M} \cdot \text{s}^{-1}$, and there is initially 0 M CO_2 , what is the $[\text{CO}_2]$ after 10 minutes have passed?

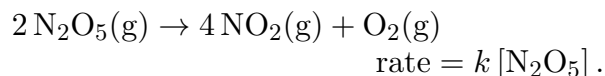
1. 0.62 M
2. 1.03 M
3. 0.10 M
4. 6.18 M **correct**

Explanation:

$$\begin{aligned} [\text{O}_2] &= [\text{O}_2]_0 + k t \\ &= 0 + (1.03 \times 10^{-2}) (600) \\ &= 6.18 \text{ M} \end{aligned}$$

008 4.0 points

Consider the reaction



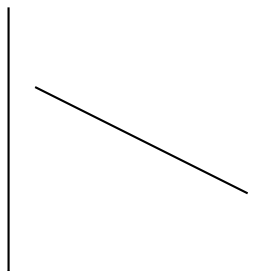
If the initial concentration of N_2O_5 is 0.80 M , what is the concentration after 5 half-lives?

1. 0.032 M
2. 0.11 M
3. 0.050 M
4. 0.16 M
5. 0.025 M **correct**

Explanation:

009 4.0 points

The following graph is for a first order reaction.



Which are the appropriate units for the axes?

1. x -axis: time; y -axis: $[\text{A}]_0$
2. x -axis: time; y -axis: E_a
3. x -axis: $\frac{1}{\text{temperature}}$; y -axis: E_a
4. x -axis: time; y -axis: $\ln[\text{A}]$ **correct**
5. x -axis: temperature; y -axis: E_a
6. x -axis: time; y -axis: k
7. x -axis: $\frac{1}{\text{temperature}}$; y -axis: $\frac{1}{k}$
8. x -axis: $\frac{1}{\text{time}}$; y -axis: $\ln[\text{A}]$
9. x -axis: time; y -axis: $\frac{1}{[\text{A}]}$
10. x -axis: $\frac{1}{\text{time}}$; y -axis: $[\text{A}]$

Explanation:

010 4.0 points

Based on the molecular model of chemical reactions discussed in class, which of the following is not required for a reaction to occur?

1. A certain minimum amount of energy.
2. A collision between the molecules which appear in the net chemical equation. **correct**
3. A collision between the species involved in the mechanism.
4. The proper orientation between reacting species.

Explanation:

A collision between species in the net reaction is not necessarily required; for example, if the net reaction is not the mechanism.

011 4.0 points

According to transition state theory and the potential energy curves used to explain it, which of the following is incorrect?

1. The change in internal energy for a reaction, differs from ΔE for the reverse reaction only by a change in sign.

2. Reactants pass through a short-lived intermediate state before forming products.

3. The energy of activation for the forward reaction is always less than that for the reverse reaction. **correct**

4. Free energy of activation is always positive.

5. Reactants pass through a high-energy transition state before forming products.

Explanation:

012 4.0 points

If a certain reaction has an activation energy E_a of $0.5 \text{ kJ} \cdot \text{mol}^{-1}$, at approximately what temperature would the reaction take place twice as fast as it does at 50 K?

1. 500 K
2. -110 K
3. 25 K
4. 125 K **correct**
5. 373 K

Explanation:

Consider the combined Arrhenius equation.

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

The question does not specify exact values for k_2 of k_1 but it does stipulate that their ratio is 2 (their exact values could be 26 and 13 or 100 and 50, anything so long as k_2 is twice as large as k_1). In addition, E_a and T_1 are provided, leaving only one unknown variable T_2 . For our units to cancel, it is convenient to express the E_a as $500 \text{ J} \cdot \text{mol}^{-1}$ rather than $0.5 \text{ kJ} \cdot \text{mol}^{-1}$.

$$\ln(2) = \frac{500}{8.314} \left(\frac{1}{50} - \frac{1}{T_2} \right)$$

$$0.693 = \frac{500}{8.314} \left(\frac{1}{50} - \frac{1}{T_2} \right)$$

Since the problem asks for an approximate answer, you should make the math as simple as possible for by judicious rounding and looking for rearrangements that make the math simpler. For example, if you round $\ln 2$ to 0.7 and multiply both sides by 8.314, the equation becomes easier to evaluate.

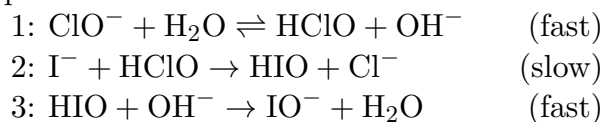
$$0.7 \times 8.314 = 500 \left(\frac{1}{50} - \frac{1}{T_2} \right)$$

The left side of the equation is now approximately 6 and the right side of the equation is easier to evaluate because we can distribute 500 into the parentheses.

$$\begin{aligned} 6 &= \frac{500}{50} - \frac{500}{T_2} \\ 6 &= 10 - \frac{500}{T_2} \\ \frac{500}{T_2} &= 10 - 6 \\ &= 4 \\ T_2 &= 500/4 \\ &= 125 \text{ K} \end{aligned}$$

013 4.0 points

The mechanism proposed for the oxidation of the iodide ion by the hypochlorite ion in aqueous solution is as follows:



How many intermediates are there in this mechanism?

1. 1
2. 0
3. 2
4. 3 **correct**

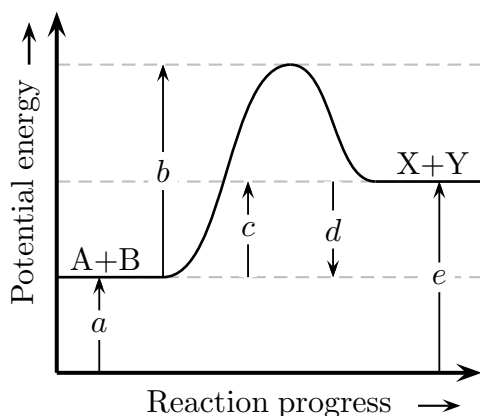
5. 4

Explanation:

There are three intermediates HClO , OH^- , and HIO

014 4.0 points

Consider the following potential energy diagram.



If a catalyst were added, which arrow would change, and how?

1. the length of arrow a would be larger.
2. the length of arrow b would be larger.
3. the length of arrow c would be larger.
4. the length of arrow d would be larger.
5. the length of arrow a would be smaller.
6. the length of arrow e would be smaller.
7. the length of arrow b would be smaller. **correct**

Explanation:**015 4.0 points**

In a catalytic converter, one of the general sets of reactions is a reduction. It is _____.

1. carbon monoxide being converted to carbon dioxide.
2. carbon dioxide being converted into methane.

3. nitrogen oxides being converted to nitrogen gas. **correct**

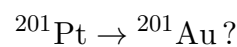
4. incomplete combustion products being converted to carbon dioxide.

Explanation:

The catalytic substrate in catalytic converters accelerates several reactions. These include the reduction of various nitrogen oxides (N_xO_y) to nitrogen gas (N_2).

016 4.0 points

What type of particle is emitted in the transformation



1. β particle **correct**
2. No particle is emitted because electron capture occurs.
3. positron
4. α particle
5. γ particle

Explanation:**017 4.0 points**

Calculate the time required for the activity of a 9.0 mCi cobalt-60 source to decay to 8.5 mCi. The half-life of cobalt-60 is 5.26 years.

1. 2.3 months
2. 4.6 months
3. 0.090 months
4. 5.2 months **correct**
5. 10 months

Explanation:**018 4.0 points**

The following reaction



is found to follow the rate law

$$\text{rate} = k[A][B]$$

when will a plot of $\ln[A]$ vs time yield a straight line?

1. when $[B] = [A]$
2. when the $[B] \gg [A]$ **correct**
3. never
4. always
5. when the $[B] \ll [A]$

Explanation:

The reaction is first order in A and B. For the plot of $\ln[A]$ vs time to yield a straight line plot the reaction must be only first order in A. This can be effectively achieved by making the concentration of $[B]$ so high that during the course of the reaction it is not changing. Then the reaction is pseudo-first order in A.