[Chapter 20 Worksheet 2

Name:

UGA myID:

Instructions:

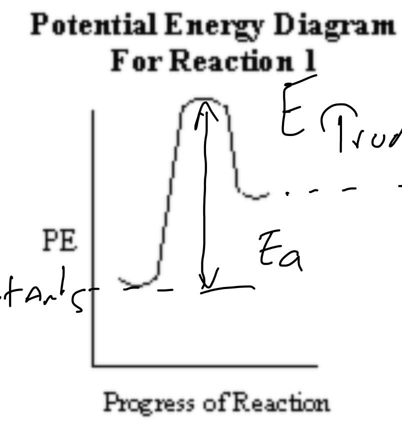
- Please enter your first and last name as it appears on the eLC roster (do not use a nickname).
- Your UGA myID is a combination of letters and numbers (example: mine is aw00285). **Do not use your 81x number.**
- If you do not have a printer, type your answers in the boxes then upload the worksheet template to Gradescope by **Thursday, February 4th at 11:59 p.m.** Write your work on separate sheets of paper, convert to a PDF and upload to the dropbox on eLC.
- If you have a printer download the worksheet, write your answers and show your work on the worksheet template, convert it to a PDF and upload to Gradescope by **Thursday, February 4th at 11:59 pm.**

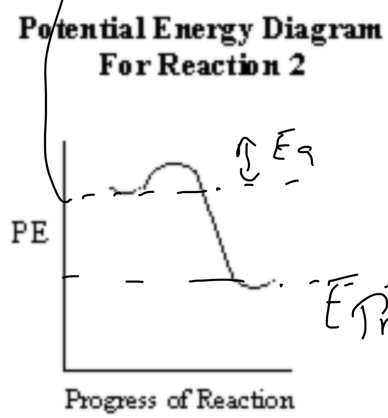
Ea (Rxn 1) > Ea (Rxn 2) / E Reactants

Chapter 20-Part 2

Question 1: What can be stated about the two potential energy diagrams shown below with respect to their relative rates of reaction and heat exchange?

E





A. Reaction 1 proceeds faster than reaction 2; Reaction 1 is exothermic and reaction 2 is endothermic.
B. Reaction 1 proceeds faster than reaction 2. Reaction 1 is endothermic and reaction 2 is exothermic.
C. Reaction 1 proceeds faster than reaction 2. Both reactions are exothermic.
D. Reaction 2 proceeds faster than reaction 1. Reaction 1 is exothermic and reaction 2 is endothermic.
E. Reaction 2 proceeds faster than reaction 1. Reaction 1 is endothermic and reaction 2 is exothermic.

R = 8.3145 J/mol·K 313.15 K 293.15 K

Question 2: The rate constant for a reaction at 40.0 C is exactly 4 times that at 20.0 °C. Calculate the Arrhenius energy of activation for the reaction.

E.

A. 4.00 kJ/mol
B. 6.36 kJ/mol
C. None of these.
D. 11.5 kJ/mol
E. 52.8 kJ/mol

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

$$\ln 4 = -\frac{E_A}{8.3145}(0.00341 + 0.00319)$$

$$11.526 = (-E_A)(0.00022)$$

Question 3: Dinitrogen tetraoxide, N_2O_4, decomposes to nitrogen dioxide, NO_2, in a first-order process. If $k = 2.5 \times 10^3\ s^{-1}$ at –5°C and $k = 3.5 \times 10^4\ s^{-1}$ at 25°C, what is the activation energy for the decomposition?

B.

A. 0.73 kJ/mol
B. 58 kJ/mol
C. 140 kJ/mol
D. 580 kJ/mol
E. >1000 kJ

$$\ln\left(\frac{3.5\times10^4}{2.5\times10^3}\right) = -\frac{E_A}{8.3145}\left(\frac{1}{298.15} - \frac{1}{268.15}\right)$$

$$21.942 = -E_A(-0.000375290)$$

$$E_A = 58474.64\ J$$

Question 4: For the overall reaction

$2A + B \rightarrow C$

which of the following mechanisms are consistent with a rate equation of rate = $k[A]^2[B]$?

A. $A + B \leftrightarrows I$ (fast) and $I + A \rightarrow C$ (slow)
B. $A + B \rightarrow I$ (slow) and $I + A \rightarrow C$ (fast)
C. $2A + B \leftrightarrows I$ (fast) and $I + B \rightarrow C$ (slow)
D. $2A \leftrightarrows I$ (fast) and $I + B \rightarrow C$ (slow)
E. Answers a and d are both correct.

Question 5:
A possible mechanism for the decomposition of ozone to oxygen in the atmosphere is:

$O_3(g) \leftrightarrows O_2(g) + O$. (fast equilibrium)

$O + O_3(g) \rightarrow 2O_2(g)$. (slow)

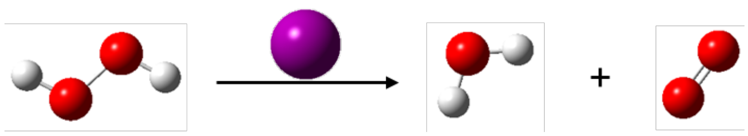
A. rate = $k[O_3]$
B. rate = $k[O_3]^2$
C. rate = $k[O_3] \times [O]$
D. rate = $k[O_3]^2 \times [O_2]$
E. rate = $k[O_3]^2 \times [O_2]^{-1}$

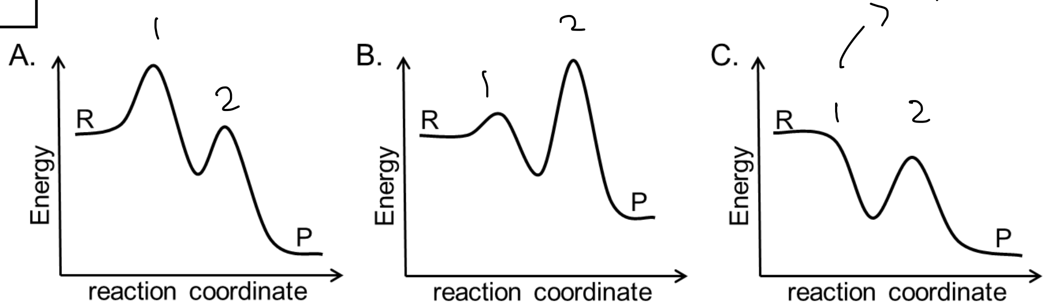
Question 6: The elementary steps for a catalyzed reaction are shown below. Identify the catalyst? Identify the reactive intermediate?

$H_2O_2(aq) + I^-(aq) \rightarrow H_2O(l) + IO^-(aq)$
$IO^-(aq) + H_2O_2(aq) \rightarrow H_2O(l) + O_2(g) + I^-(aq)$

A. The catalyst is $H_2O(l)$; the reactive intermediate is $I^-(aq)$.
B. The catalyst is $IO^-(aq)$; the reactive intermediate is $I^-(aq)$.
C. The catalyst is $I^-(aq)$; the reactive intermediate is $H_2O_2(aq)$.
D. The catalyst is $I^-(aq)$; the reactive intermediate is $IO^-(aq)$.
E. The catalyst is $H_2O_2(aq)$; the reactive intermediate is $I^-(aq)$.

Question 7: The exothermic iodide catalyzed decomposition of peroxide was determined to occur via two separate steps in which the first step is the rate determining step. Which of the following three potential energy diagrams best summarizes these findings.





Question 8: Given the following proposed mechanism, predict the rate law for the overall reaction.

E

$A_2 + 2B \rightarrow 2AB$ (overall reaction)

Mechanism

$A_2 \rightleftharpoons 2A$ fast

$A + B \rightarrow AB$ slow

A. Rate = $k[A][B]$
B. Rate = $k[A_2][B]$
C. Rate = $k[A_2][B]^{1/2}$
D. Rate = $k[A_2]$
E. Rate = $k\,[A_2]^{1/2}[B]$

Rate forward = Rate reverse, A = intermediate

$k_1 [A_2] = k_{-1} [A]^2$

$[A] = \left(\frac{k_1}{k_{-1}}\right)^{1/2} \cdot [A_2]^{1/2}$

Rate "slow" = $k'[A][B] = k[A_2]^{1/2} \cdot [B]$

Question 9: A mechanism for a naturally occurring reaction that destroys ozone is:

HO

Step 1: $O_3(g) + HO(g) \rightarrow HO_2(g) + O_2(g)$
Step 2: $HO_2(g) + O(g) \rightarrow HO(g) + O_2(g)$

Which species is a catalyst? , It is a reactant in step 1 and a product in step 2.

Question 10: A gaseous reaction occurs by a two-step mechanism, shown below.

$k[AX]^2[Y_2]$

Step 1: $AX + Y_2 \rightleftharpoons AXY_2$ fast

Step 2: $AXY_2 + AX \rightarrow 2\,AXY$ slow → $k'[AXY_2][AX]$

What is the rate law for this reaction?

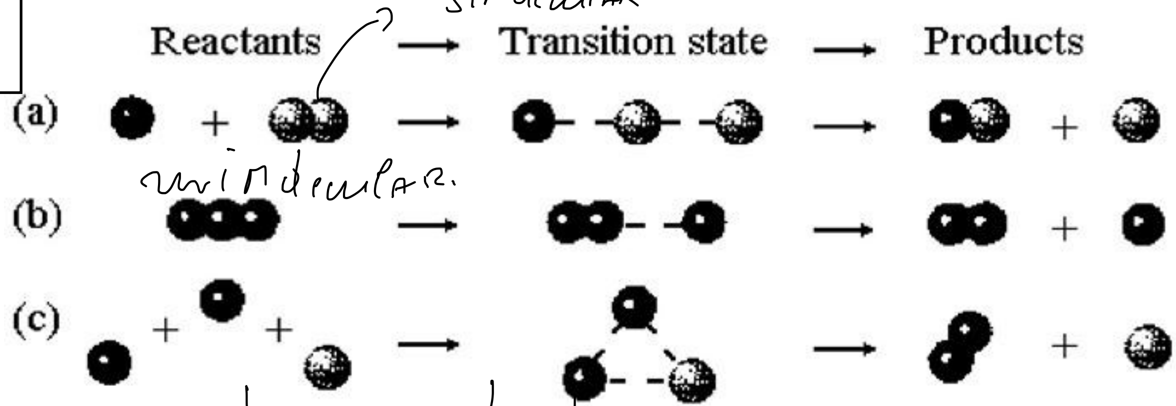
$k_1 [AX][Y_2] = k_{-1} [AXY_2]$,

$[AXY_2] = (k_1/k_{-1})\,[AX][Y_2]$

Rate = $k[AX]^2[Y_2]$

Question 11: Which of the elementary reactions shown has a molecularity of one?

B



bimolecular

unimolecular.

termolecular

Question 12: A reaction occurs via the following sequence of elementary steps. What is the rate law based on this reaction mechanism?

$k[A][C]$

1st step: $A \rightleftharpoons B$ very fast

2nd step: $B + C \rightarrow D$ slow Rate = $k'[B][C]$

3rd step: $D \rightarrow 2E$ fast

B: intermediate

$k_1 [A] = k_{-1} [B]$, $[B] = \frac{k_1}{k_{-1}} [A]$

Rate = $k[A][C]$

Question 13: Which of the following statements best describes the condition(s) needed for a successful formation for a product according to the collision model?

A, E

A. a greater fraction of the collisions have the correct orientation of molecules.
B. the activation energy of the reaction will increase.
C. the activation energy of the reaction will decrease.
D. temperature acts as a catalyst in chemical reactions.
E. more collisions will have enough energy to exceed the activation energy.

Question 14: Which of the following statements best describes the condition(s) needed for a successful formation for a product according to the collision model?

D

A. The relative orientation of the particles has an effect only if the kinetic energy of the particles is below some minimum value.
B. The collision must involve a sufficient amount of energy, provided from the motion of the particles, to overcome the activation energy.
C. The relative orientation of the particles must allow for formation of the new bonds in the product.
D. The energy of the incoming particles must be above a certain minimum value, and the relative orientation of the particles must allow for formation of new bonds in the product.
E. The relative orientation of the particles has little or no effect on the formation of the product.

Question 15:
What is the rate law for the following reaction and its mechanism?

→ Intermediate

$2\ HgCl_2 + C_2O_4^{2-} \rightarrow 2\ Cl^- + 2\ CO_2 + Hg_2Cl_2$ (overall reaction)
$HgCl_2 + C_2O_4^{2-} \rightleftharpoons HgCl_2C_2O_4^{2-}$ (fast)
$HgCl_2C_2O_4^{2-} + C_2O_4^{2-} \rightarrow Hg + 2\ C_2O_4Cl^{2-}$ (slow) ⇒ $Rate = k'[HgCl_2C_2O_4^{2-}][C_2O_4^{2-}]$
$Hg + HgCl_2 \rightarrow Hg_2Cl_2$ (fast)
$2\ C_2O_4Cl^{2-} \rightarrow C_2O_4^{2-} + 2Cl^- + 2\ CO_2$ (fast)

$k_1[HgCl_2][C_2O_4^{2-}] = k_{-1}[HgCl_2C_2O_4^{2-}]$

$[HgCl_2C_2O_4^{2-}] = \frac{k_1}{k_{-1}}[HgCl_2][C_2O_4^{2-}]$

D

A. Rate = $k[HgCl_2][C_2O_4^{2-}]$
B. Rate = $k[HgCl_2]^2[C_2O_4^{2-}]$
C. Rate = $k[Hg_2Cl_2]$
D. Rate = $k[HgCl_2][C_2O_4^{2-}]^2$
E. Rate = $k[HgCl_2]^2[C_2O_4^{2-}]^2$

Rate ⇒ $Rate = k[HgCl_2][C_2O_4^{2-}]$

Question 16: For the second order reaction A → products, the following data are obtained:

[A] = 3.024 M, t = 0 min
[A] = 2.935 M, t = 1.0 min
[A] = 2.852 M, t = 2.0 min

What is the rate constant, k?

E

A. $3.6 \times 10^{-3}\ M^{-1}\ min^{-1}$
B. $1.4 \times 10^{-2}\ M^{-1}\ min^{-1}$
C. $2.2 \times 10^{-2}\ M^{-1}\ min^{-1}$
D. $9.7 \times 10^{-3}\ M^{-1}\ min^{-1}$
E. $1.0 \times 10^{-2}\ M^{-1}\ min^{-1}$

$$\frac{1}{[A]_t} = \frac{1}{[A]_0} + k \cdot t$$

$$\left(\frac{1}{2.935}\right) = \left(\frac{1}{3.024}\right) + k(1.00)$$

$$1.003 \times 10^{-2} = k$$

$$k = 1.0 \times 10^{-2}$$