Dougherty Valley HS Chemistry - AP
Kinetics – Kinetics FRQs

Worksheet #9

Name: **Period:** **Seat#:**

Directions: Show all work in a way that would earn you credit on the AP Test! Use binder paper to show work.

1) Consider the reaction, 8 A + 5 B → 8 C + 6 D. If [C] is increasing at the rate of 4 M/s, at what rate is [B] decreasing?

(A) 0.40 M/s (B) 2.5 M/s (C) 4.0 M/s (D) 6.4 M/s (E) -2.5 M/s

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2) Consider the reaction, 5 A + 3 B → 9 C + 7 D. If A is being used up at the rate of 15 M/s, how quickly is D being made?

(A) 7 M/s (B) 14 M/s (C) 21 M/s (D) 10.7 M/s (E) 1.4 M/s

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3) If, at a particular moment, ammonia is formed at a rate of 0.50 M/s from the reaction $N_2(g) + 3H_2(g) \rightarrow 2\ NH_3(g)$, what is the rate of disappearance of N_2 and that of H_2 from the reaction?

(A) N_2: 0.25 M/s; H_2, 0.75 M/s
(B) N_2: 0.25 M/s; H_2, 0.25 M/s
(C) N_2: 0.25 M/s; H_2, 0.33 M/s
(D) N_2: 0.50 M/s; H_2, 0.50 M/s
(E) N_2: 0.75 M/s; H_2, 0.50 M/s

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4) In the reaction, $CO + 3\ H_2 \rightarrow CH_4 + H_2O$, which rate expression below is incorrect?

(A) $-\Delta[CO]/\Delta t = -\Delta[H_2]/3\Delta t$
(B) $\Delta[CH_4]/\Delta t = \Delta[H_2O]/\Delta t$
(C) $-\Delta[CO]/\Delta t = \Delta[H_2O]/\Delta t$
(D) $-3\Delta[H_2]/\Delta t = \Delta[H_2O]/\Delta t$
(E) $-\Delta[CO]/\Delta t = \Delta[CH_4]/\Delta t$

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5) The rate law for a chemical reaction is determined by

(A) theoretical calculations.
(B) measuring reaction rate as a function of concentration of reacting species.
(C) determining the equilibrium constant for the reaction.
(D) measuring reaction rates as a function of temperature.

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6) The rate law for a chemical reaction:

(A) can be determined from the stoichiometry of the overall reaction
(B) can be determined from the fastest step of the mechanism
(C) can only be determined by using computer simulation
(D) can be determined by measuring rate as a function of reactant concentration
(E) can be determined by measuring rate a function of temperature

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7) The value of the rate constant of a reaction can generally be expected to

(A) be independent of temperature.
(B) increase with increasing temperature.
(C) decrease with increasing temperature.
(D) decrease with increasing temperature only if the reaction is exothermic.

8) The following question concerns the reaction, a A + b B $\rightarrow$ c C + d D for which the reaction rate may be written, rate = $k[A]^n[B]^m$ where [A] is the concentration of A and [B] is the concentration of B. Which of the following statements is true?

(A) k depends on how long the reaction has been going
(B) k depends on temperature but never pressure
(C) k depends on temperature
(D) k depends on [reactants]
(E) k depends on the concentration of the products

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9) Some chemical reactions proceed at a rate that is proportional to the concentration of a single reactant. Such reactions

(A) are called zero order reactions.
(B) are called first order reactions.
(C) are called second order reactions.
(D) do not occur. For a reaction to occur, at least two molecules (or ions) must collide; in this case, however, there is only one reactant

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10) The rate law for a first order reaction has the form

(A) rate = k
(B) rate = $k\,[A]^2$
(C) rate = $k\,[A]$
(D) rate = $k\,[A][B]$

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11) The rate expression for a second order reaction is

(A) rate = $k\,[A]$
(B) rate = $k\,[A]^2\,[B]$
(C) rate = $k\,[A]\,[B]$
(D) rate = $k\,[A]^2\,[B]^2$

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12) For the reaction $H_2O_2(aq) + 3\ I^-(aq) + 2\ H^+\ (aq) \rightarrow I_3^-(aq) + 2\ H_2O$, the rate law is rate = $k[H_2O_2][I^-]$. The correct description of the order of the reaction is:

(A) First order with respect to $[H_2O_2]$; first order with respect to $[I^-]$; first order with respect to $[H^+]$; and second order overall.
(B) First order with respect to $[H_2O_2]$; first order with respect to $[I^-]$; second order with respect to $[H^+]$; and first order overall.
(C) First order with respect to $[H_2O_2]$; third order with respect to $[I^-]$; second order with respect to $[H^+]$; and sixth order overall.
(D) First order with respect to $[H_2O_2]$; first order with respect to $[I^-]$; zero order with respect to $[H^+]$; and second order overall.

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13) 2A + 3D $\rightarrow$ products is 1st order in A and 2nd order in D. What is the rate law in the form, rate =

(A) $k[A][D]$
(B) $k[A]^2[D]^3$
(C) $k[A][D]^2$
(D) $k[A]^2[D]$
(E) $k[A]^2[D]^2$

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14) The rate law for the reaction, **A** + **B** $\rightarrow$ **C** + **D**, is first order in [**A**] and second order in [**B**]. If [**A**] is halved and [**B**] is doubled, the rate of the reaction will

(A) remain the same.
(B) be increased by a factor of 2.
(C) be increased by a factor of 4.
(D) be increased by a factor of 8

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15) The gas–phase reaction, $\mathbf{A_2} + \mathbf{B_2} \rightarrow 2\mathbf{AB}$, proceeds by collisions between $\mathbf{A_2}$ and $\mathbf{B_2}$ molecules. If the concentrations of both $\mathbf{A_2}$ and $\mathbf{B_2}$ are doubled, the reaction rate will be changed by a factor of

(A) 1/2
(B) 2
(C) 3
(D) 4
(E) $\sqrt{2}$

16) If a reaction proceeding by the mechanism, **A** + **B** → **C** + **D**, occurs at a rate *x*, and if the concentrations of **A** and **B** are both doubled, what will be the new rate of reaction?

(A) *x* (B) 2*x* (C) 4*x* (D) 8*x* (E) 16*x*

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17) For the reaction between gaseous chlorine and nitric oxide, $2NO_{(g)} + Cl_{2(g)} \rightarrow 2NOCl_{(g)}$, doubling the concentration of chlorine doubles the rate of reaction. Doubling the concentrations of both reactants increases the rate by a factor of eight. The reaction is

(A) first order in NO, first order in Cl_2.
(B) first order in NO, second order in Cl_2.
(C) second order in NO, second order in Cl_2.
(D) second order in NO, first order in Cl_2.

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18) The reaction, 5 A + 3 B + 2 C → products has a rate law that is 1st order in A, 1st order in B, and 2nd order in C. Which of the following changes in concentrations will have NO EFFECT upon the rate?

(A) double [A], double [B], double [C]
(B) halve [A], double [B], double [C]
(C) double [A], halve [B], double [C]
(D) double [A], double [B], halve [C]
(E) halve [A], double [B], halve [C]

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19) For the reaction **A** + 2**B** → $\mathbf{AB_2}$, determine the rate law given this data:

Exp.	[A]	[B]	Rate
1	0.23 M	0.17 M	0.33 M/h
2	0.46 M	0.17 M	0.67 M/h
3	0.23 M	0.51 M	1.00 M/h

(A) rate = *k* [A][B]
(B) rate = *k* [A][B]^2
(C) rate = *k* [A]^2 [B]
(D) rate = *k* [A]^2 [B]^2

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20) Consider the reaction between CH_3Cl and NaOH to give CH_3OH and NaCl. Calculate the rate law for this reaction given the data:

Experiment	Init. [CH_3Cl]	Init. [NaOH]	Rate (M/s)
1	0.36	0.25	3.7
2	0.72	0.25	7.4
3	1.44	0.50	29.6

(A) Rate = k[CH_3Cl]^2[NaOH]
(B) Rate = k[CH_3Cl][NaOH]^2
(C) Rate = k[CH_3Cl]
(D) Rate = k[CH_3Cl]^2[NaOH]^2
(E) Rate = k[CH_3Cl][NaOH]

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21) The table presents data for the reaction, $2H_{2(g)} + 2NO_{(g)} \rightarrow 2H_2O_{(g)} + N_{2(g)}$. What is the rate law?

Exp.	[NO]	[H_2]	Rate
1	6.0	1.0	18
2	6.0	2.0	36
3	1.0	6.0	3
4	2.0	6.0	12

(A) rate = *k*[H_2][NO]
(B) rate = *k*[H_2]^2[NO]
(C) rate = *k*[H_2]^2[NO]^2
(D) rate = *k*[H_2][NO]^2

22) Calculate the value of the rate constant in question 19:

(A) 0.12 (B) 19 (C) 27 (D) 8.4

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23) For the reaction **A** + **B** → **C** these data were obtained. What is the rate law?

Exp.	[A]	[B]	Rate
1	0.10 M	0.10 M	0.030 M/h
2	0.10 M	0.20 M	0.120 M/h
3	0.20 M	0.20 M	0.120 M/h

(A) rate = k[A][B] (B) rate = $k[A]^2[B]$ (C) rate = $k[A]^2$ (D) rate = $k[B]^2$

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24) Initial rate data for the reaction, $2N_2O_{5(g)} \rightarrow 4NO_{2(g)} + O_{2(g)}$ are as follows. What is the rate law:

Exp.	$[N_2O_5]$	$[O_2]$	Rate
1	0.15 M	0.30 M	46 M/s
2	0.20 M	0.60 M	61 M/s
3	0.20 M	0.30 M	61 M/s

(A) rate = $k[N_2O_5]$ (B) rate = $k[N_2O_5]^1[O_2]^2$ (C) rate = $k[[N_2O_5]^2$ (D) rate = $k[N_2O_5]^2[O_2]$

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25) The data below were measured for the reaction, 2A + 2B + 2C → D. Calculate the rate law

Exp.	[A]	[B]	[C]	rate (M/min)
1	0.25	0.20	1.0	5.1
2	0.25	0.40	2.0	20.4
3	0.25	0.40	1.0	20.4
4	0.50	0.20	1.0	10.2

(A) rate = $k[A]^2[B]^2[C]^2$ (B) rate = $k[A][B][C]^2$ (C) rate = $k[A][B]^2[C]$
(D) rate = $k[A][B]^2$ (E) rate = k[A][B][C]

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26) The decomposition of diethylether at 504 °C is first order with a half-life of 1570 seconds. What fraction of the original sample will remain after 4710 seconds?

(A) 1/16 (B) 1/8 (C) 1/3 (D) 1/6 (E) 1/32

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27) A first order reaction has the rate law, rate = k[A]. The half life of this reaction is:

(A) $t_{1/2} = (\log_{10} 2)/k$ (B) $t_{1/2} = -(\ln 2) / k$ (C) $t_{1/2} = (\ln 2)/k$
(D) $t_{1/2} = 1 / k[A]_o$ (E) $t_{1/2} = (\ln 2) \times k$

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28) For the rxn, 2 NOBr(g) → 2 NO(g) + Br_2(g), the rate law is rate = $k[NOBr]^2$ and the rate constant is 0.80 1/Ms. What is the concentration of NOBr after 22 s if the starting concentration is 0.086 M?

(A) 7.1×10^{-11} M (B) 8.4×10^{11} M (C) 0.086 M
(D) 1.2×10^{-12} M (E) 0.034 M

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29) The reaction of cyclopropane to propene is first order, with a rate constant of 5.4×10^{-2} hr^{-1} at 25 °C. If I start with 0.150 M cyclopropane, how much will be left after 22.0 hours?

(A) 0.0457 M (B) 0.105 M (C) 0.127 M (D) 0.492 M (E) 0 M

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30) The half-life for the first-order decomposition of the radioactive nucleus, ^{241}U is 15 seconds. If I make 50 g of this nucleus, how long will it take until I only have 6.25 g left?

(A) 30 seconds (B) 45 seconds (C) 60 seconds (D) 75 seconds (E) 90 seconds

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31) The rate law for the reaction, 3 A → C is rate = 4.36×10^{-2} $[A]^2$, where k is given as 1/Mh What is the half life for the reaction if the initial concentration of A is 0.250 M?

(A) 0.0109 h (B) 0.0629 h (C) 15.9 h (D) 91.7 h (E) 4.36×10^{-2} h

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32) $2\ NO_2 \rightarrow 2\ NO + O_2$ follows second order kinetics. At 300 °C, it takes 100 s for the $[NO_2]$ to drop from 0.0100 to 0.00650 M. What is the value of k in 1/Ms?

(A) 0.096 (B) 0.65 (C) 0.81 (D) 1.2 (E) 0.54

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33) $CH_3NC \rightarrow CH_3CN$ is a first order reaction. At 230.3 °C, k = 6.30×10^{-4} s^{-1}. If I start with 0.001 M $[CH_3NC]$, how much is left after 1000 s?

(A) 0.000533 (B) 0.00234 (C) 0.00188 (D) 0.00427

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34) The value of k for a particular second-order reaction is 0.47 1/Ms. If the initial concentration of the reactant is 0.25 M, how long will it take for the concentration to decrease to 0.13 mol/L?

(A) 7.9 s (B) 1.4 s (C) 3.7 s (D) 1.7 s

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35) Substance **A** undergoes a first order reaction **A** → **B** with a half life of 20 min at 25 °C. If the initial concentration of **A** in a sample is 1.6 M, what will be the concentration of **A** after 80 min?

(A) 0.40 M (B) 0.20 M (C) 0.10 M (D) 0.050 M

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36) The decomposition of hydrogen peroxide is a first order reaction with k = 1.06×10^{-3} min^{-1}. How long will it take for 40% of a sample of hydrogen peroxide to decompose?

(A) 7.55 min (B) 481 min (C) 4550 min (D) 31,400 min

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37) The decomposition of $SOCl_2$ is first order. If the half life for the reaction is 4.1 h, how long would it take for the concentration of $SOCl_2$ to drop from 0.36 M to 0.045 M?

(A) 0.52 h (B) 1.4 h (C) 12 h (D) 33 h

38) A change in temperature from 10 °C to 20 °C is found to double the rate of a given chemical reaction. How did this change affect the reacting molecules?

(A) It doubled their average velocity. (B) It doubled their average energy.
(C) It doubled the number of collisions per second.
(D) It doubled the pressure inside the reaction vessel.
(E) It doubled the proportion of molecules possessing at least the minimum energy required for the reaction.

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39) How is the activation energy E_a determined from measurements of the rate constants as a function of temperature?

(A) Plot ln K as a function of 1/T, where T is measured in degrees Celsius
(B) Plot K as a function of 1/T, where T is measured in degrees Kelvin
(C) Plot K as a function of T, where T is measured in degrees Kelvin
(D) Plot ln K as a function of 1/T, where T is measured in degrees Kelvin
(E) Plot ln K as a function of T, where T is measured in degrees Celsius

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40) The kinetics of the decomposition of dinitrogen pentoxide are studied at 50 °C and 75 °C. Which of the following statements about these studies is correct?

(A) The rate at 75 °C will be greater than that at 50 °C because the activation energy is lower at 75 °C
(B) The rate at 75 °C will be greater than that at 50 °C because the number of molecules with enough energy to react increases with temperature
(C) The rate at 75 °C will be lower than that at 50 °C because the molecules with higher speeds do not interact as well as the ones at lower speeds
(D) The rate at 75 °C will be greater than that at 50 °C because the concentration of a gas increases with increasing temperature
(E) The rate at 75 °C will be greater than that at 50 °C because the activation energy is higher.

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41) The Arrhenius equation, $k = Ae^{-E/RT}$ expresses the relationship between the rate constant, *k*, and the energy of activation, *E*. The probability that colliding molecules will react

(A) increases with increasing energy of activation.
(B) depends only on the empirical constant, *A*.
(C) increases with decreasing temperature.
(D) decreases with increasing energy of activation.

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42) 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?

(A) 0.73 kJ/mol (B) 58 kJ/mol (C) 140 kJ/mol (D) 580 kJ/mol

43) The decomposition of hydrogen peroxide in the presence of iodide ion is believed to occur via the mechanism below. In this mechanism, $I^-_{(aq)}$ is

1. $H_2O_{2(aq)} + I^-_{(aq)} \rightarrow H_2O_{(l)} + IO^-_{(aq)}$
2. $H_2O_{2(aq)} + IO^-_{(aq)} \rightarrow H_2O_{(l)} + O_{2(g)} + I^-_{(aq)}$

(A) a catalyst.
(B) a reactant in the overall reaction.
(C) the activated complex.
(D) a product of the overall reaction.

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44) The following mechanism has been proposed for the formation of ethylbenzene: Which substance is not an intermediate?

$CH_3CH_2Br + AlBr_3 \rightarrow AlBr_4^- + CH_3CH_2^+$
$CH_3CH_2^+ + C_6H_6 \rightarrow C_6H_6CH_2CH_3^+$
$C_6H_6CH_2CH_3^+ + AlBr_4^- \rightarrow AlBr_3 + HBr + C_6H_5CH_2CH_3$

(A) $AlBr_3$
(B) $CH_3CH_2^+$
(C) $AlBr_4^-$
(D) $C_6H_6CH_2CH_3^+$

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45) Consider the reaction:, $2NO_{2(g)} + F_{2(g)} \rightarrow 2NO_2F_{(g)}$. A proposed mechanism for this reaction is shown below. What is the rate law for this mechanism?

1. $NO_2 + F_2 \rightarrow NO_2F + F$ (slow)
2. $NO_2 + F \rightarrow NO_2F$ (fast)

(A) rate = $k\dfrac{[NO_2F]^2}{[NO_2]^2[F_2]}$
(B) rate = $k[NO_2][F_2]$
(C) rate = $k[NO_2]^2[F_2]$
(D) rate = $k[NO_2][F]$

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46) The reaction, $2\,NO(g) + O_2(g) \rightarrow 2\,NO_2(g)$, has an observed rate law, rate = $k[NO]^2[O_2]$. Three possible mechanisms could be proposed for this reaction, as shown:

MECHANISM I. Second step slow.

1. $NO(g) + NO(g) \rightarrow N_2O_2(g)$
2. $N_2O_2(g) + O_2(g) \rightarrow 2\,NO_2(g)$

MECHANISM II. First step slow.

1. $NO(g) + NO(g) \rightarrow N_2O_2(g)$
2. $N_2O_2(g) + O_2(g) \rightarrow 2\,NO_2(g)$

MECHANISM III. One step reaction, $2\,NO(g) + O_2(g) \rightarrow 2\,NO_2(g)$

Which of these mechanisms is the most likely?

(A) I only
(B) II only
(C) III only
(D) I and III
(E) II and III

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47) Consider the following mechanism of the oxidation of bromide ions by hydrogen peroxide in acid solution. Which of the rate laws in the answers is consistent with this mechanism?

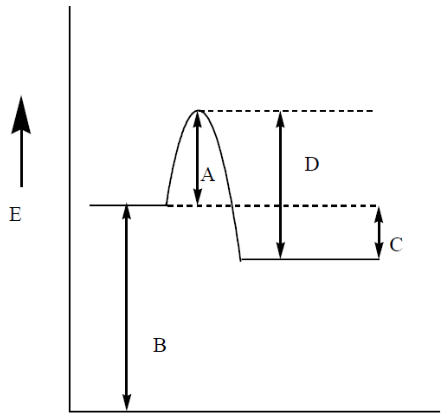
1. $H^+ + H_2O_2 \rightarrow H_2O\text{-}OH^+$ Fast
2. $H_2O\text{-}OH^+ + Br^- \rightarrow HOBr + H_2O$ Slow
3. $HOBr + H^+ + Br^- \rightarrow Br_2 + H_2O$ Fast

(A) Rate = $k[H_2O_2][Br^-][H^+]^2$
(B) Rate = $k[H_2O_2][Br^-][H^+]$
(C) Rate = $k[H_2O\text{-}OH^+][Br^-]$
(D) Rate = $k[H_2O_2][Br^-]^2[H^+]^2$
(E) Rate = $k[HOBr][H^+][Br^-][H_2O_2]$

48) In a chemical reaction involving the formation of an activated complex (transition state), which step must always be exothermic?

(A) Reactants → products
(B) Products → reactants
(C) Reactants → activated complex
(D) Products → activated complex
(E) Activated complex → products

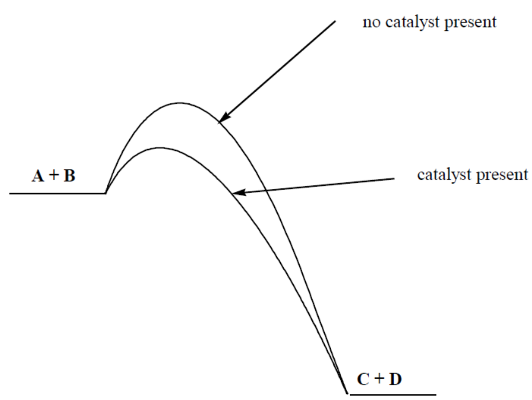
49) Which line in the diagram represents the activation energy for a forward reaction?



(A) A (B) B (C) C (D) D

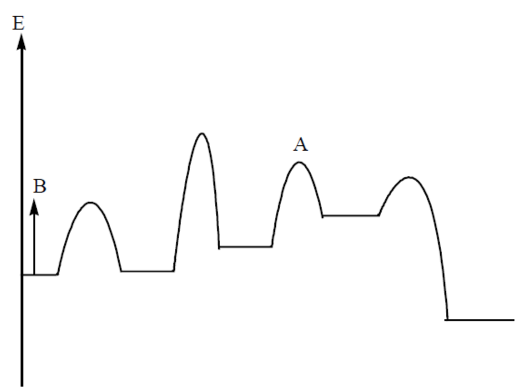
50) Which statement concerning the reaction coordinate diagram is true?

(A) The catalyst decreases the activation energy.
(B) The reaction is endothermic.
(C) The addition of a catalyst slows this reaction.
(D) **A** and **B** have lower potential energy than **C** and **D**.



51) Consider the reaction coordinate shown below, and pick the correct statement:

(A) the point A represents at set of intermediates
(B) the energy represented by B is the activation energy
(C) there are five steps in the mechanism
(D) the second step is the rate-determining step
(E) there are four sets of intermediates in the reaction mechanism



52) The rate of a reaction in the absence of a catalyst has been measured. The rate of the same reaction when catalyzed is 106 times faster. The activation energy for this reaction

(A) is 6/*RT* kcal/mole.
(B) can be calculated from the information above if the temperatures of the reactions are given.
(C) is a concept that cannot be applied to chemical reactions.
(D) is different in the two cases.

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53) The addition of a catalyst in a chemical reaction

(A) increases the concentration of products at equilibrium.
(B) increases the fraction of reactant molecules with a given kinetic energy.
(C) provides an alternate path with a different activation energy.
(D) lowers the enthalpy change in the overall reaction.

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54) Which procedure will lower the activation energy for a particular reaction?

(A) subdividing the reactants
(B) increasing the reactant concentrations
(C) increasing the temperature
(D) adding a catalyst

ANSWERS:

1. B
2. C
3. A
4. D
5. B
6. D
7. B
8. C
9. B
10. C
11. C
12. D
13. C
14. B
15. D
16. C
17. D
18. D
19. A
20. E
21. D
22. D
23. D
24. A
25. D
26. B
27. C
28. E
29. A
30. B
31. D
32. E
33. A
34. A
35. C
36. B
37. C
38. E
39. D
40. B
41. D
42. B
43. A
44. A
45. B
46. A
47. B
48. E
49. A
50. A
51. D
52. D
53. C
54. D