Pretest 1

Multiple Choice
Identify the choice that best completes the statement or answers the question.

1. Which one of the following thermodynamic quantities is not a state function?
   a. work
   b. enthalpy
   c. entropy
   d. internal energy
   e. free energy

2. The enthalpy change, ΔH, of a process is defined as:
   a. The maximum amount of useful work that can be done in a system.
   b. The increase or decrease in temperature in a system.
   c. The quantity of heat transferred in or out of a system as it undergoes a change at constant pressure.
   d. The change in molecular disorder in a system.
   e. None of these are correct.

3. A system is compressed from 50.0 L to 5.0 L at a constant pressure of 10.0 atm. What is the amount of work done?
   a. 2.5 \times 10^5 J
   b. 450 J
   c. 4.6 \times 10^4 J
   d. −450 J
   e. −4.6 \times 10^4 J

4. If 4.168 kJ of heat is added to a calorimeter containing 75.40 g of water, the temperature of the water and the calorimeter increases from 24.58°C to 35.82°C. Calculate the heat capacity of the calorimeter (in J/°C). The specific heat of water is 4.184 J/g•°C.
   a. 622 J/°C
   b. 55.34 J/°C
   c. 315.5 J/°C
   d. 25.31 J/°C
   e. 17.36 J/°C

5. A 50.0 mL solution of 1.2 M HCl at 24.1°C is mixed with 50.0 mL of 1.3 M NaOH, also at 24.1°C, in a coffee-cup calorimeter. After the reaction occurs, the temperature of the resulting mixture is 29.8°C. The density of the final solution is 1.05 g/mL. Calculate the molar heat of neutralization. Assume the specific heat of the solution is 4.184 J/g•°C. The heat capacity of the calorimeter is 32.5 J/°C.
   a. 41.7 kJ/mol
   b. 58.5 kJ/mol
   c. 44.8 kJ/mol
   d. 13.0 kJ/mol
   e. 33.9 kJ/mol

6. The burning of 80.3 g of SiH₄ at constant pressure gives off 3790 kJ of heat. Calculate ΔH for this reaction.
SiH\(_4\) + 2O\(_2\) → SiO\(_2\) + 2H\(_2\)O

a. -1520 kJ/mol rxn  
b. -47.2 kJ/mol rxn  
c. -4340 kJ/mol rxn  
d. -2430 kJ/mol rxn  
e. +4340 kJ/mol rxn

7. Given the following at 25°C and 1.00 atm:
   1/2N\(_2\) + O\(_2\) → NO\(_2\)  \(\Delta H^0 = 33.2\) kJ
   N\(_2\) + 2O\(_2\) → N\(_2\)O\(_4\)  \(\Delta H^0 = 11.1\) kJ

   Calculate the \(\Delta H^0\) for the reaction below at 25°C.
   2NO\(_2\) → N\(_2\)O\(_4\)

   a. +11.0 kJ  
b. +44.3 kJ  
c. +55.3 kJ  
d. -22.1 kJ  
e. -55.3 kJ

8. Given the standard heats of formation for the following compounds, calculate \(\Delta H^0_{f,298}\) for the following reaction.
   \[
   \begin{array}{ccc}
   \text{CH}_4(g) & + & \text{H}_2\text{O}(g) & \rightarrow & \text{CH}_3\text{OH}(\ell) & + & \text{H}_2(g) \\
   -75 & & -242 & & -238 & & 0 \\
   \end{array}
   \]

   a. +79 kJ  
b. -79 kJ  
c. +594 kcal  
d. -594 kcal  
e. -405 kJ

9. Estimate the heat of reaction at 298 K for the reaction shown, given the average bond energies below.
   \[\text{Br}_2(g) + 3\text{F}_2(g) \rightarrow 2\text{BrF}_3(g)\]

   \[
   \begin{array}{c|c}
   \text{Bond} & \text{Bond Energy} \\
   \hline
   \text{Br–Br} & 193 \text{ kJ/mol} \\
   \text{F–F} & 155 \text{ kJ/mol} \\
   \text{Br–F} & 249 \text{ kJ/mol} \\
   \end{array}
   \]

   a. -836 kJ  
b. -150 kJ  
c. -89 kJ  
d. -665 kJ  
e. -1222 kJ

10. Which of the following is not a formation reaction?
a. \( \frac{1}{2} \text{H}_2(g) + \frac{1}{2} \text{Br}_2(\ell) \rightarrow \text{HBr}(g) \)
b. \( \text{H}_2(g) + \frac{1}{2} \text{O}_2(g) \rightarrow \text{H}_2\text{O}(\ell) \)
c. \( \text{Ca}(s) + \frac{1}{2} \text{O}_2(g) \rightarrow \text{CaO}(s) \)
d. \( 4\text{Al}(s) + 3\frac{1}{2} \text{O}_2(g) \rightarrow \text{Al}_2\text{O}_3(s) \)
e. \( \text{H}_2\text{O}(\ell) + \text{SO}_3(\ell) \rightarrow \text{H}_2\text{SO}_4(\ell) \)

11. Which one of the following statements is false? For a reaction carried out at constant temperature and constant pressure in an open container, _____.

a. the work done by the system can be set equal to \(-P\Delta V\)
b. the work done by the system can be set equal to \(V\Delta P\)
c. the work done by the system can be set equal to \(-\Delta nRT\) where \(\Delta n\) is the number of moles of gaseous products minus the number of moles of gaseous reactants
d. the heat absorbed by the system can be called \(q_p\)
e. the heat absorbed by the system can be called \(\Delta H\)

12. The heat of vaporization of methanol, \( \text{CH}_3\text{OH} \), is 35.20 kJ/mol. Its boiling point is 64.6°C. What is the change in entropy for the vaporization of methanol?

a. \(-17.0\ \text{J/mol} \cdot \text{K}\)
b. \(3.25\ \text{J/mol} \cdot \text{K}\)
c. \(17.0\ \text{J/mol} \cdot \text{K}\)
d. \(104\ \text{J/mol} \cdot \text{K}\)
e. \(543\ \text{J/mol} \cdot \text{K}\)

13. Use the data below to calculate \(\Delta H^\circ\) for benzene, \( \text{C}_6\text{H}_6(\ell) \), at 25°C and 1 atm.

\[
\begin{align*}
2\text{C}_6\text{H}_6(\ell) + 15\text{O}_2(g) & \rightarrow 12\text{CO}_2(g) + 6\text{H}_2\text{O}(\ell) \\
\Delta H^\circ &= -6535 \text{ kJ} \\
\Delta H^\circ_{\text{fCO}_2(g)} &= -393.5 \text{ kJ/mol}, \\
\Delta H^\circ_{\text{fH}_2\text{O}(l)} &= -285.8 \text{ kJ/mol}
\end{align*}
\]

a. \(49.1\ \text{kJ/mol}\)
b. \(3.51 \times 10^4\ \text{kJ/mol}\)
c. \(103\ \text{kJ/mol}\)
d. \(1.76 \times 10^7\ \text{kJ/mol}\)
e. \(561\ \text{kJ/mol}\)

14. Calculate the standard energy change, \(\Delta E^\circ\), for the reaction below.

\[
\begin{align*}
12\text{NH}_3(g) + 21\text{O}_2(g) & \rightarrow 8\text{HNO}_3(\ell) + 4\text{NO}(g) + 14\text{H}_2\text{O}(g) \\
\Delta H^\circ_{\text{f}} &= -45.9\ \text{kJ/mol} \quad 0 \quad -133.9 \quad 91.3 \quad -241.8
\end{align*}
\]

a. \(-3,540\ \text{kJ/mol}\)
b. \(-201.3\ \text{kJ/mol}\)
c. \(-2,259\ \text{kJ/mol}\)
d. \(-4270\ \text{kJ/mol}\)
e. \(-3,503\ \text{kJ/mol}\)

15. What is the entropy change of the reaction below at 298 K and 1 atm pressure?

\[
\text{N}_2(g) + 3\text{H}_2(g) \rightarrow 2\text{NH}_3(g)
\]
16. Which chemical change listed below represents a decrease in entropy?
   a. \( \text{N}_2(g) + 3\text{H}_2(g) \rightarrow \text{NH}_3(g) \)
   b. \( \text{CaCO}_3(s) \rightarrow \text{CaO}(s) + \text{CO}_2(g) \)
   c. \( 2\text{NO}_2(g) \rightarrow \text{N}_2(g) + 2\text{O}_2(g) \)
   d. \( 2\text{C}_6\text{H}_6 + 15\text{O}_2(g) \rightarrow 12\text{CO}_2(g) + 6\text{H}_2\text{O}(g) \)
   e. \( 2\text{NaCl}(\ell) \rightarrow 2\text{Na}(\ell) + \text{Cl}_2(g) \)

17. Which of the following statements regarding the third law of thermodynamics is incorrect?
   a. The absolute \( S \) is zero at 0 Kelvin.
   b. The absolute \( S \) at 298 K can be positive or negative.
   c. Pure substances have positive absolute \( S \) at \( T > 0 \) Kelvin.
   d. Absolute zero gives a reference point for determining absolute \( S \).
   e. The absolute \( S \) is greater at 300 K than 100 K for a given substance.

18. A process occurs spontaneously and \( \Delta S_{\text{system}} < 0 \). Which statement below must be true?
   a. \( \Delta S_{\text{surroundings}} > 0 \)
   b. \( \Delta S_{\text{universe}} > 0 \)
   c. The pressure is constant.
   d. Both (a) and (b) are correct.
   e. All of these answers are correct.

19. For a particular reaction at 25°C, \( \Delta H^0 = -297 \text{ kJ/mol} \), and \( \Delta S^0 = -113.3 \text{ J/mol•K} \). At which of the following temperatures would the reaction become spontaneous?
   a. 2750 K
   b. 3250 K
   c. 2450 K
   d. 10500 K
   e. 3750 K

20. Calculate \( \Delta G^0 \) for the reaction below. The standard molar entropy change for the reaction at 298 K is -287.5 J/mol•K.
\[
3\text{NO}_2(g) + \text{H}_2\text{O}(\ell) \rightarrow 2\text{HNO}_3(aq) + \text{NO}(g) + 136.8 \text{ kJ}
\]
   a. -51.2 kJ/mol
   b. 85,500 kJ/mol
   c. -68.4 kJ/mol
   d. -236 kJ/mol
   e. -222 kJ/mol

21. Evaluate \( \Delta G^0 \) for the reaction below at 25°C.
\[
\Delta G_f^0 \quad 2\text{C}_2\text{H}_2(g) + 5\text{O}_2(g) \rightarrow 4\text{CO}_2(g) + 2\text{H}_2\text{O}(l)
\]

\begin{align*}
209.2 & \quad 0 & \rightarrow & \quad -394.4 & \quad -237.2 \\
\text{kJ/mol}
\end{align*}

a. \(-1409 \text{ kJ}\)
b. \(-2599 \text{ kJ}\)
c. \(-1643 \text{ kJ}\)
d. \(-2470 \text{ kJ}\)
e. \(-766 \text{ kJ}\)

22. For which set of values of \(\Delta H\) and \(\Delta S\) will a reaction be spontaneous (product-favored) at all temperatures?

a. \(\Delta H = +10 \text{ kJ}, \Delta S = -5 \text{ J/K}\)
b. \(\Delta H = -10 \text{ kJ}, \Delta S = -5 \text{ J/K}\)
c. \(\Delta H = -10 \text{ kJ}, \Delta S = +5 \text{ J/K}\)
d. \(\Delta H = +10 \text{ kJ}, \Delta S = +5 \text{ J/K}\)
e. no such values exist

23. In the following reaction, the rate of formation of \(\text{NH}_3\) is 0.15 mol/L\(\cdot\)min. What is the rate of reaction?

\[\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3\]

a. 0.15 mol/L\(\cdot\)min
b. 0.075 mol/L\(\cdot\)min
c. \(-0.075 \text{ mol/L}\(\cdot\)min\)
d. 0.20 mol/L\(\cdot\)min
e. 0.30 mol/L\(\cdot\)min

24. Suppose a reaction \(\text{A} + \text{B} \rightarrow \text{C}\) occurs at some initial rate at 25°C. Which response includes all of the changes below that \textbf{could} increase the rate of this reaction?

I. lowering the temperature
II. adding a catalyst
III. increasing the initial concentration of B

a. I
b. II
c. III
d. I and II
e. II and III

25. The gas phase reaction \(\text{A} + \text{B} + \text{C} \rightarrow \text{D}\) has a reaction rate which is experimentally observed to follow the relationship \(\text{rate} = k[\text{A}]^2[\text{C}]\). The reaction is _____ order in A, _____ order in B, and _____ order in C.

a. first; second; third
b. first; second; zero
c. second; zero; first
d. second; first; zero
e. second; zero; zero
26. A hypothetical reaction \( X + 2Y \rightarrow \text{Products} \) is found to be first order in \( X \) and second order in \( Y \). What are the units of \( k \), the specific rate constant, if reaction rate is expressed in units of moles per liter per second?
   a. \( M \cdot s^{-1} \)
   b. \( M^2 \cdot s^{-1} \)
   c. \( M^3 \cdot s \)
   d. \( M \cdot s^{-1} \)
   e. \( M^2 \cdot s \)

27. A troublesome reaction that is responsible in part for acid rain is
   \[ \text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_2\text{SO}_4 \]

Rate data have been determined at a particular temperature for the reaction in which all reactants and products are gases.

<table>
<thead>
<tr>
<th>Trial Run</th>
<th>Initial [SO(_3)]</th>
<th>Initial [H(_2)O]</th>
<th>Initial Rate (M(\cdot)s(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.35 (M)</td>
<td>0.35 (M)</td>
<td>0.150</td>
</tr>
<tr>
<td>2</td>
<td>0.70 (M)</td>
<td>0.35 (M)</td>
<td>0.600</td>
</tr>
<tr>
<td>3</td>
<td>0.35 (M)</td>
<td>0.70 (M)</td>
<td>0.300</td>
</tr>
<tr>
<td>4</td>
<td>0.70 (M)</td>
<td>0.70 (M)</td>
<td>1.20</td>
</tr>
</tbody>
</table>

The rate-law expression is ____.
   a. \(\text{rate} = k[\text{SO}_3]^2[\text{H}_2\text{O}]^2\)
   b. \(\text{rate} = k[\text{SO}_3]^2[\text{H}_2\text{O}]\)
   c. \(\text{rate} = k[\text{SO}_3][\text{H}_2\text{O}]^2\)
   d. \(\text{rate} = k[\text{SO}_3]^2[\text{H}_2\text{O}]\)
   e. \(\text{rate} = k[\text{SO}_3][\text{H}_2\text{O}]\)

28. A plot of \(\frac{1}{[D]}\) versus time is linear for the reaction \( D \rightarrow E \). What is the kinetic order of the reaction?
   a. second
   b. first
   c. zero
   d. one-half
   e. negative one

29. The rate constant for the first order reaction below is \( k = 3.3 \times 10^{-2} \text{ min}^{-1} \) at 57 K. What is the half-life for this reaction at 57 K?
   \[ \text{A} \rightarrow \text{B} + \text{C} \]
   a. 21 min
   b. 30 min
   c. 61 min
   d. 9.1 min
   e. 1200 min

30. A molecule of ethyl alcohol is converted to acetaldehyde in one's body by zero order kinetics. If the concentration of alcohol is 0.015 mol/L and the rate constant = \( 6.4 \times 10^{-5} \text{ mol/L} \cdot \text{min} \), what is the concentration of alcohol after 3.5 hours?
   a. 0.0016 mol/L
The specific rate constant, $k$, for a reaction is $2.64 \times 10^{-2}$ s$^{-1}$ at 25°C, and the activation energy is 74.0 kJ/mol. Calculate $k$ at 50°C. (The universal gas constant = 8.314 J/mol•K.)

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

32. Which of the following statements about catalysts are false?
   a. A catalyst lowers the activation energy.
   b. A catalyst can make a nonspontaneous reaction spontaneous.
   c. A catalyst speeds up both the forward and reverse reaction.
   d. A catalyst speeds up the rate of reaction.
   e. Catalyst are often transition metals and transition metal oxides.

33. Consider the hypothetical reaction shown below.
   \[ A + 2B \rightarrow AB_2 \]

Assume that the following proposed mechanism is consistent with the rate data.

\[
\begin{align*}
B & \rightarrow B_2 & \text{slow} \\
B_2 & \rightarrow A \rightarrow AB + B & \text{fast} \\
B & \rightarrow AB \rightarrow AB_2 & \text{fast} \\
A & \rightarrow 2B \rightarrow AB_2 & \text{overall}
\end{align*}
\]

Which one of the following statements must be true? The reaction is ____. 
   a. first order in A, second order in B, and third order overall 
   b. second order in B and second order overall 
   c. first order in A and first order overall 
   d. second order in B, zero order in A, and third order overall 
   e. second order in A and second order overall 

34. Which idea listed below is not a part of the collision theory of reaction rates?
   a. Molecules must be properly oriented when they collide to react. 
   b. Molecules must collide to react. 
   c. Molecules must collide with enough kinetic energy to overcome the potential energy stabilization of the bonds. 
   d. Effective collisions result in a chemical reaction. 
   e. All molecular collisions result in a reaction.

35. Which statement is incorrect?
a. Energy is the capacity to do work or to transfer heat.
b. Kinetic energy is the energy of motion.
c. Potential energy is the energy that a system possesses by virtue of its position or composition.
d. A process that absorbs energy from its surroundings is called exothermic.

36. How much heat is absorbed in the complete reaction of 3.00 grams of SiO\(_2\) with excess carbon in the reaction below? \(\Delta H^0\) for the reaction is +624.6 kJ.

\[
\text{SiO}_2(g) + 3\text{C}(s) \rightarrow \text{SiC}(s) + 2\text{CO}(g)
\]

a. 366 kJ
b. 1.13 \times 10^5 kJ
c. 5.06 kJ
d. 1.33 \times 10^4 kJ
e. 31.2 kJ

37. Which statement concerning sign conventions for \(\Delta E = q + w\) is false?

a. For heat absorbed by the system, \(q\) is positive.
b. For work done by the system, \(w\) is negative.
c. When energy is released by the reacting system, \(\Delta E\) is negative.
d. If \(\Delta E\) is positive, energy can be written as a product in the equation for the reaction.
e. For an expansion, \(w\) is negative.

38. A 1.00-g sample of hexane, \(\text{C}_6\text{H}_{14}\), undergoes complete combustion with excess \(\text{O}_2\) in a bomb calorimeter. The temperature of the 1500. g of water surrounding the bomb rises from 22.64°C to 29.30°C. The heat capacity of the calorimeter is 4.04 kJ/°C. What is \(\Delta E\) for the reaction in kJ/mol of \(\text{C}_6\text{H}_{14}\)? The specific heat of water is 4.184 J/g•°C.

a. \(-9.96 \times 10^3\) kJ/mol
b. \(-4.52 \times 10^3\) kJ/mol
c. \(-1.15 \times 10^4\) kJ/mol
d. \(-7.40 \times 10^4\) kJ/mol
e. \(-5.91 \times 10^3\) kJ/mol

39. A positive change in entropy represents:

a. an increase in dispersal of matter (molecular disorder)
b. release of thermal energy
c. a decrease in thermal energy
d. a process that is always spontaneous
e. a process that cannot occur spontaneously

40. Consider the conversion of a substance from solid to liquid.

\[
\text{Solid} \underset{\text{Liquid}}{\longrightarrow}
\]

At one atmosphere pressure and at the melting point of the substance, ____.

a. \(\Delta H = 0\) for the process
b. \(\Delta S = 0\) for the process
c. \(\Delta E = 0\) for the process
d. \(\Delta G = 0\) for the process
41. **Estimate** the temperature at which $\Delta G = 0$ for the following reaction.

\[ \text{NH}_3(g) + \text{HCl}(g) \rightarrow \text{NH}_4\text{Cl}(s) \]

\[ \Delta H = -176 \text{ kJ}; \quad \Delta S = -284.5 \text{ J/K} \]

- a. 467 K
- b. 582 K
- c. 619 K
- d. 634 K
- e. 680 K

42. For a certain process at 127°C, $\Delta G = -16.20 \text{ kJ}$ and $\Delta H = -17.0 \text{ kJ}$. What is the entropy change for this process at this temperature? Express your answer in the form, $\Delta S = ____ \text{ J/K}$.

- a. $-6.3 \text{ J/K}$
- b. $+6.3 \text{ J/K}$
- c. $-2.0 \text{ J/K}$
- d. $+2.0 \text{ J/K}$
- e. $-8.1 \text{ J/K}$

43. One of the reactions that is used to produce gaseous hydrogen commercially follows. A proper expression for the rate of this reaction could be ____.

\[ \text{H}_2\text{O}(g) + \text{CO}(g) \rightarrow \text{H}_2(g) + \text{CO}_2(g) \]

- a. $-\Delta \left[ \frac{\text{CO}_2}{\text{t}} \right]$ \\
- b. $-\Delta \left[ \frac{\text{H}_2}{\text{t}} \right]$ \\
- c. $k$ \\
- d. $\Delta \left[ \frac{\text{CO}}{\text{t}} \right]$ \\
- e. $-\Delta \left[ \frac{\text{H}_2\text{O}}{\text{t}} \right]$ \\

44. Consider the exothermic combustion of coal. Which of the following could increase the rate of reaction?

- a. using smaller pieces of coal
- b. increasing the concentration of oxygen
- c. lowering the temperature
- d. both (a) and (b) are correct
- e. choices (a), (b) and (c) are all correct

45. A reaction $A + 2B \rightarrow C$ is found to be first order in $A$ and first order in $B$. What are the units of the rate constant, $k$, if the rate is expressed in units of moles per liter per minute?

- a. $M^{-1} \text{min}^{-1}$
- b. $M$
- c. $M \text{min}^{-1}$
- d. $\text{min}^{-1}$
46. The gas-phase reaction
   \[ 2\text{NO} + 2\text{H}_2 \rightarrow \text{N}_2 + 2\text{H}_2\text{O} \]
   has the following rate law expression, \( \text{rate} = 0.14 \text{ L}^2/\text{mol}^2 \cdot \text{s}[\text{NO}]^2[\text{H}_2] \). If the [NO] is 0.95 M and the [H\(_2\)] is 0.45 M, what rate is expected?
   a. 0.060 mol/L \cdot s
   b. 0.43 mol/L \cdot s
   c. 0.027 mol/L \cdot s
   d. 1.54 mol/L \cdot s
   e. 0.057 mol/L \cdot s

47. Evaluate the specific rate constant for the reaction at the temperature for which the data were obtained. The rate-law expression is \( \text{rate} = k[\text{A}][\text{B}]^2 \).
   A + B → C

   \[
   \begin{array}{ccc}
   \text{Experiment} & \text{Initial [A]} & \text{Initial [B]} & \text{Initial Rate of Formation of C} \\
   1 & 0.10 \text{ M} & 0.10 \text{ M} & 4.0 \times 10^{-4} \text{ M/min} \\
   2 & 0.20 \text{ M} & 0.20 \text{ M} & 3.2 \times 10^{-3} \text{ M/min} \\
   3 & 0.10 \text{ M} & 0.20 \text{ M} & 1.6 \times 10^{-3} \text{ M/min} \\
   \end{array}
   \]
   a. \( 1.2 \times 10^{-2} \text{ M}^2 \cdot \text{min}^{-1} \)
   b. \( 3.6 \times 10^{-2} \text{ M}^2 \cdot \text{min}^{-1} \)
   c. \( 4.0 \times 10^{-1} \text{ M}^2 \cdot \text{min}^{-1} \)
   d. \( 6.2 \times 10^{-1} \text{ M}^2 \cdot \text{min}^{-1} \)
   e. \( 7.0 \times 10^{-3} \text{ M}^2 \cdot \text{min}^{-1} \)

48. The half-life of the zero order reaction below is 0.56 minutes. If the initial concentration of A is 3.4 M, what is the rate constant?
   A → B
   a. 6.07 mol/L \cdot min
   b. 1.24 mol/L \cdot min
   c. 3.04 mol/L \cdot min
   d. 0.619 mol/L \cdot min
   e. 1.79 mol/L \cdot min

49. The second order reaction below has a rate constant of 5.76 \( \text{ M}^{-1} \cdot \text{min}^{-1} \) at 1600 K.
   \[ 2\text{CH}_4 \rightarrow \text{C}_2\text{H}_2 + 3\text{H}_2 \]

   How long would it take for the concentration of CH\(_4\) to be reduced from 0.89 M to \( 5.25 \times 10^{-4} \) M?
   a. 165 hrs
   b. 0.15 hrs
   c. 2.75 hrs
   d. 5.51 hrs
   e. 9.27 hrs

50. Which of the following statements regarding collision and transition state theory is false?
   a. Reactants must collide to form products.
b. All reactant collisions result in product formation.
c. Activation energy is always positive.
d. Reactant molecules must absorb energy to form the transition state.
e. Reactant collisions must be oriented properly to form products.

51. A reaction has an activation energy of 40 kJ and an overall energy change of reaction of $-100$ kJ. In each of the following potential energy diagrams, the horizontal axis is the reaction coordinate and the vertical axis is potential energy in kJ. Which potential energy diagram best describes this reaction?

a. 

b. 

c. 

d. 

e. 

52. Reaction rates increase with increasing temperature because ____.
   a. the activation energy increases
   b. larger molecules collide more frequently
c. the energy of the transition state is lowered  
d. the activation energy is decreased  
e. a greater fraction of molecules possess the activation energy when they collide  

53. The specific rate constant, \( k \), for a reaction is 0.44 s\(^{-1} \) at 298 K, and the activation energy is 245 kJ/mol. Calculate \( k \) at 398 K. (The universal gas constant = 8.314 J/mol\( \cdot \)K.)

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

a. \( 2.71 \times 10^{10} \text{ s}^{-1} \)  
b. \( 6.17 \times 10^{10} \text{ s}^{-1} \)  
c. \( 1.03 \times 10^{10} \text{ s}^{-1} \)  
d. \( 8.32 \times 10^{8} \text{ s}^{-1} \)  
e. \( 4.51 \times 10^{9} \text{ s}^{-1} \)  

54. A catalyst ____.

a. is used up in a chemical reaction  
b. changes the value of \( \Delta G^\circ \) of the reaction  
c. is always a solid  
d. does not influence the reaction in any way  
e. changes the activation energy of the reaction
# Pretest 1

## Answer Section

### MULTIPLE CHOICE

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