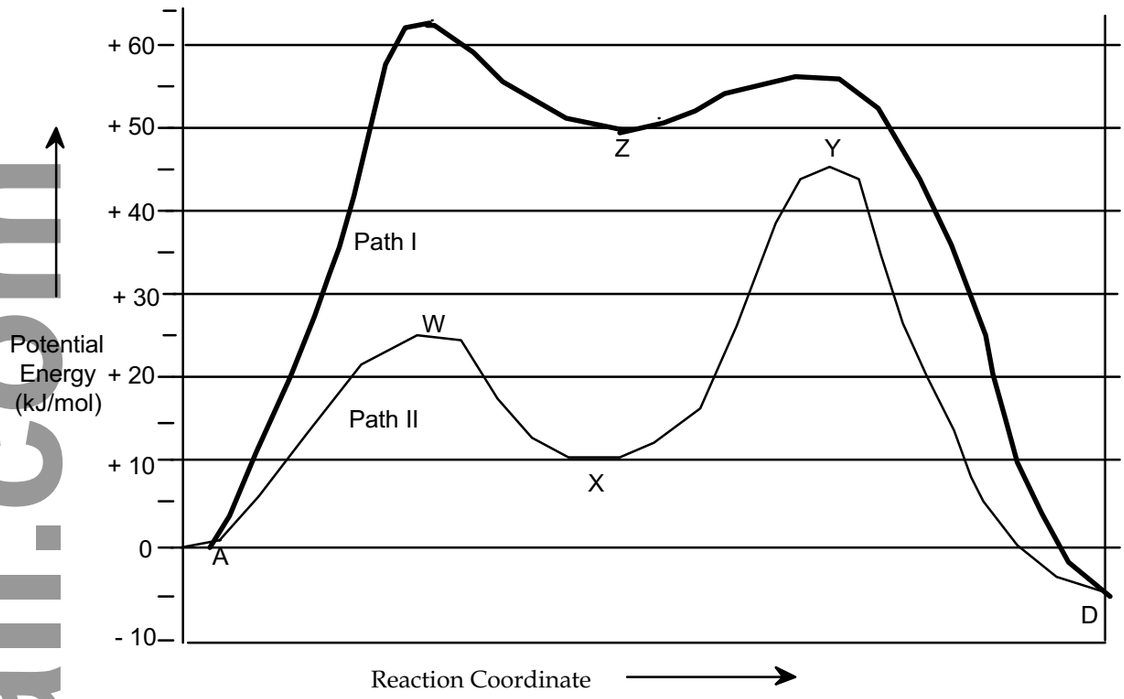
SCH OA Rates of Chemical Reactions Name: _____

Multiple Choice (18 marks)
For each of the following questions, select the most correct answer and mark that choice on the multiple choice answer sheet provided.

The next four questions refer to the following diagram. Substance A reacts to form D by two reaction paths shown below.



1. The overall heat of reaction ΔH for Reaction Path II, A ——— D is:
   a) - 20 kJ b) - 5 kJ c) + 10 kJ d) + 45 kJ e) + 70 kJ

2. The activation energy E_a, for reaction step A ——— X is:
   a) - 15 kJ b) -10 kJ c) + 10 kJ d) + 15 kJ e) + 25 kJ

3. Concerning Reaction Path II, select the statement that is FALSE:
   a) product X has a higher heat content than product D
   b) the reaction proceeds in two steps
   c) activated complexes are represented by points W, X, Y and D
   d) reaction A ——— X is endothermic
   e) the overall reaction A ——— D is exothermic

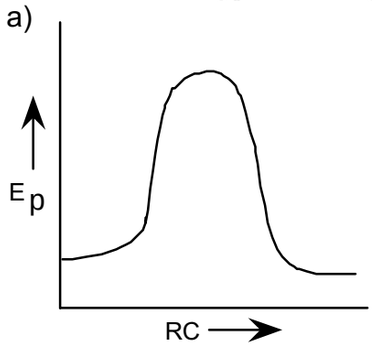
4. Which one of the following statements is TRUE? Reaction Path I for reaction A ——— D:
   a) has a higher overall heat of reaction than Path II
   b) will never be followed as long as Path II is available
   c) represents a more energetic, therefore a faster reaction path than Path II
   d) will probably be more frequently followed at high temperature than at low temperature
   e) does not involve the formation of activated complexes

5. The activation energy for an exothermic reaction is + 22.0 kJ/mol. The activation energy for the reverse reaction is:
   a) more than +22.0 kJ/mol
   b) less than +22.0 kJ/mol
   c) + 22.0 kJ/mol
   d) - 22.0 kJ/mol
   e) there is no way of knowing from the given information.

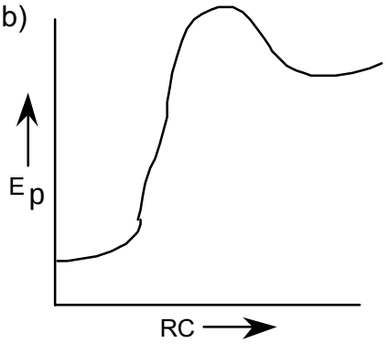
6. The rate-determining step of a reaction is
   a) always the fastest step
   b) always the first step in a reaction mechanism
   c) always the last step in a reaction mechanism
   d) always the step with the highest activation energy
   e) always the step with the least number of molecules

7. Which of the following potential energy diagrams best represent the <u>evaporation</u> of water?

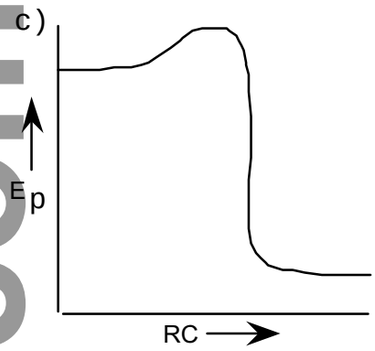
a)



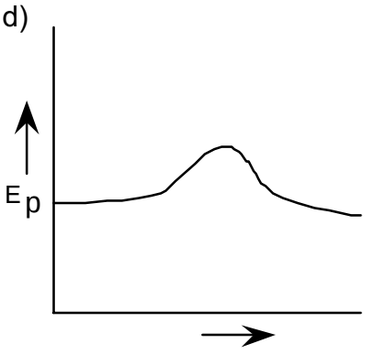
b)



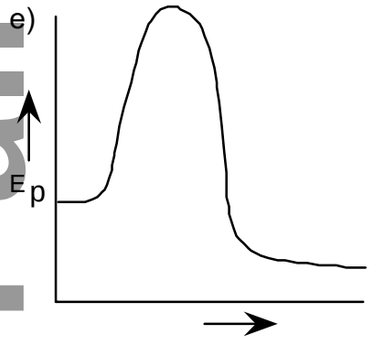
c)



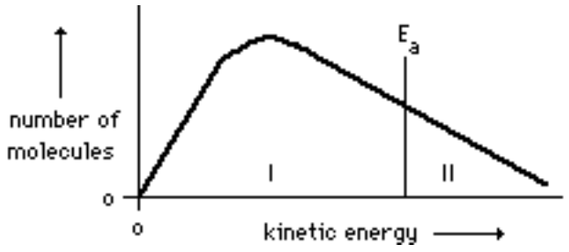
d)



e)



8. Consider the following graph of the kinetic energy distribution among molecules at temperature T.



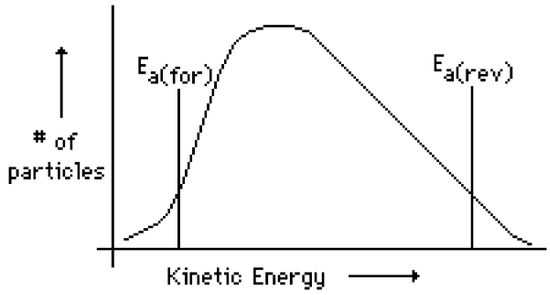
If the temperature were increased how would the resulting graph differ from the one above?

a) both areas I and II would increase
b) both areas I and II would decrease
c) area I would increase and area II would decrease
d) area I would decrease and area II would increase
e) both areas I and II would remain the same

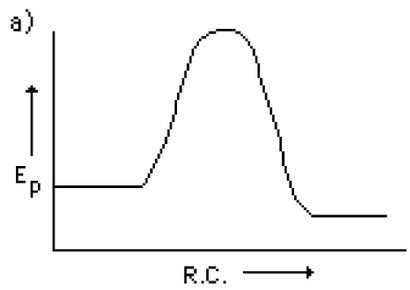
9. Concerning the factors which affect the rate of a reaction, which of the following is FALSE?

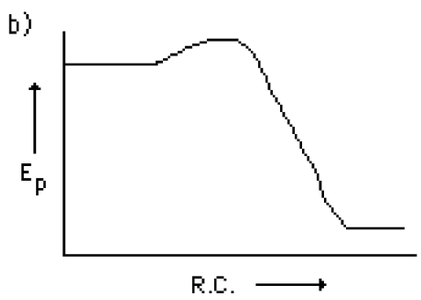
a) Increasing the concentration of the reacting particles increases the chance of collision.
b) Poor collision orientation requires a higher activation energy than a direct collision.
c) A reaction occurs each time particles of the reactants collide.
d) Increasing the temperature increases the percentage of particles with the minimum energy necessary to react.
e) A catalyst lowers the activation energy requirement.

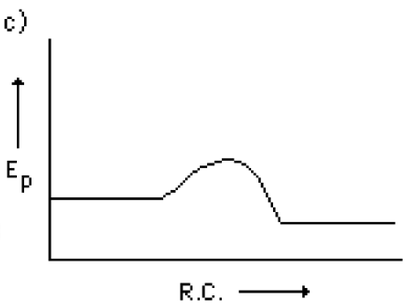
10. Examine the following kinetic energy distribution curve for a certain reaction:

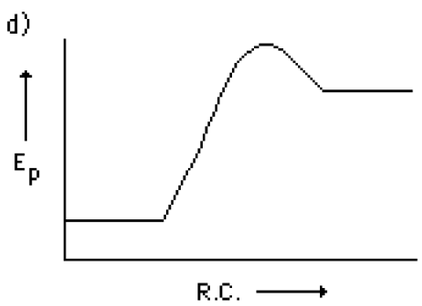


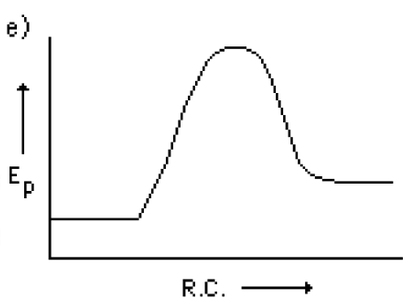
Which of the following enthalpy diagrams could represent the same reaction?











11. Which best explains why increasing concentration increases reaction rate?
    a) the collisions become more effective
    b) the average kinetic energy increases
    c) the collision frequency increases
    d) the activation energy increases
    e) the activation energy decreases

12. Consider the reaction

$$2\,C_3H_6 + 9\,O_2 \longrightarrow 6\,CO_2 + 6\,H_2O$$

If the rate of appearance of CO_2 is 0.40 mol/L/s, the rate of disappearance of O_2 is:

a) 0.10 mol/L/s
b) 0.30 mol/L/s
c) 0.60 mol/L/s
d) 0.90 mol/L/s
e) 1.2 mol/L/s

For the next two questions use the following reaction mechanism:

13. The following represents the entire mechanism for a reaction

$A + B \longrightarrow C$	slow
$C + 2A \longrightarrow D + E$	fast
$E \longrightarrow F$	fast

The overall equation for the reaction is:

a) $A + B \longrightarrow F$
b) $E \longrightarrow F$
c) $A + B \longrightarrow C$
d) $3A + B \longrightarrow D + F$
e) $3A + B + C + E \longrightarrow C + D + E + F$

14. The rate law expression for this reaction would be:
a) rate = k [A]
b) rate = k[B]
c) rate = k [A] [B]
d) rate = k $[A]^3$ [B]
e) not enough information given to determine the rate law expression

15. At room temperature, and considering only the nature of the reactants, which of the following reactions would be expected to have the slowest rate of reaction?

a) $Ca^{2+}_{(aq)} + CO_3^{2-}{}_{(aq)} \longrightarrow CaCO_{3(s)}$

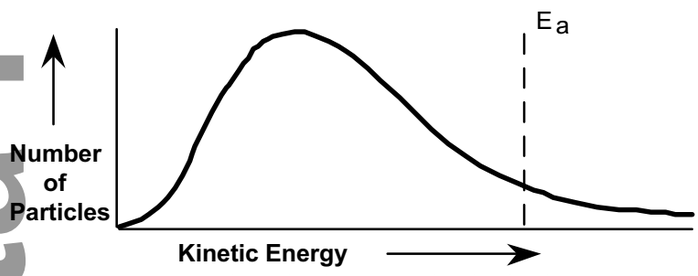
b) $2\ MnO_4^-{}_{(aq)} + 16\ H^+_{(aq)} + 5\ C_2O_4^{2-}{}_{(aq)} \longrightarrow 10\ CO_{2(g)} + 8\ H_2O_{(l)} + 2\ Mn^{2+}_{(aq)}$

c) $C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)}$

d) $2\ H_{2(g)} + O_{2(g)} \longrightarrow 2\ H_2O_{(g)}$

e) $C_2H_{6(g)} + 3.5\ O_{2(g)} \longrightarrow 2\ CO_{2(g)} + 3\ H_2O_{(g)}$

The next two questions refer to the following energy distribution curve:



(**Note**: E_a represents the activation energy barrier for the reaction)

16. If the temperature is raised
a) E_a moves left
b) E_a does not move
c) E_a moves right
d) no prediction can be made

17. If a catalyst is added
a) E_a moves left
b) E_a does not move
c) E_a moves right
d) no prediction can be made

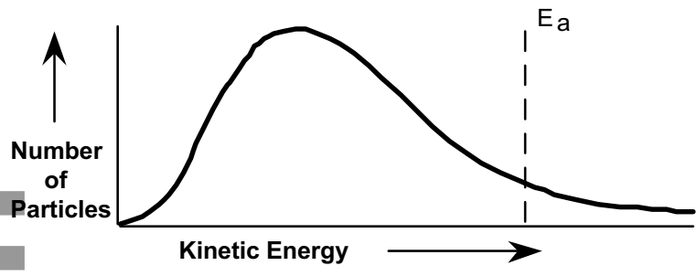
18. When lycopodium powder is heated in a spoon, it burns slowly with a yellow, sooty flame yet when it is blown through a candle flame, it burns explosively. An explanation of this observation is that:
a) the candle flame acts as a catalyst to the reaction
b) the concentration of oxygen in the flame is higher than in the air above the spoon
c) the lycopodium powder reacts with something in the candle flame
d) the exposed surface area of the powder is much larger in the flame than on the spoon
e) the heat from the flame is more concentrated, causing the lycopodium powder to reach its ignition temperature easier

Part B Short Written Answers (26 marks) Name: _____

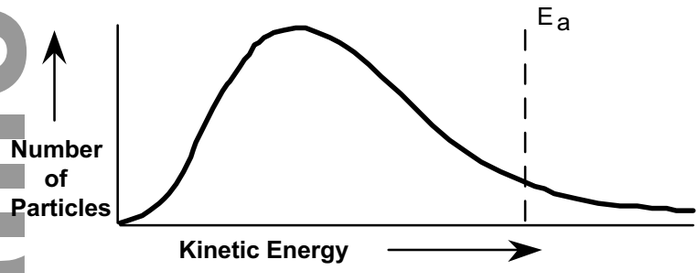
Answer all question in the spaces provided on the quest paper.

1. The following diagrams represents a chemical reaction occurring at room temperature. Draw <u>on each diagram</u> the resulting EFFECT of each of the following changes in experimental conditions:
(2 x 2 marks = 4 marks)

a) **The temperature is cooled from about 35°C to 25°C.**



b) The concentration of reactants is halved at the same temperature.



2. Sketch <u>Potential Energy diagrams</u> (E vs RC) for each of the following changes **(4 x 2 = 8 marks):**

a) the burning of a candle

b) the evaporation of gasoline (a volatile liquid - easily evaporated)

c) the dissolving of NaOH - the mixture becomes significantly warmer cooler

d) the oxidation (rusting) of iron

3. The following experimental data were obtained on the following reaction:

$$2\,H_{2(g)} + 2\,NO_{(g)} \longrightarrow N_{2(g)} + 2\,H_2O_{(g)} + 664\ kJ$$

$[H_2]$	[NO]	Intitial Rate of Decrease of Pressure (kPa/min)
1×10^{-2}	3×10^{-2}	20
2×10^{-2}	3×10^{-2}	80
1×10^{-2}	6×10^{-2}	40

a) Write the rate law expression for the reaction **(1 mark).**

b) Calculate the rate constant **(1 mark).**

c) Calculate the initial rate of reaction with initial concentrations of H_2 and NO are 0.44 mol/L and 1.24 mol/L respectively. **(1 mark)**

d) Why can the rate of reaction be measured by a pressure decrease? **(1 mark)**

4. The following graph of concentration versus time was obtained for a chemical reaction:

a) Calculate the average rate of reaction. (**2 marks)**

b) Calculate the rate of reaction at 30 s. **(2 marks)**

5. What is meant by the terms: **(3 marks)**

a) instantaneous reaction

b) rate of reaction

c) catalyst

6. The reaction between aqueous solutions of barium hydroxide and sulphuric acid can be represented by the following equation:

$Ba^{+2}_{(aq)} + 2\ OH^{-1}_{(aq)} + 2\ H^{+}_{(aq)} + SO_4^{-2}_{(aq)} \longrightarrow BaSO_{4(s)} + 2\ H_20_{(l)}$

Describe three ways in which the rate of this reaction could be measured. Give reasons for each of the ways you mentioned. **(3 marks)**

BONUS: Draw an energy diagram (E vs R.C.) for an alpha decay reaction. Give reasons for drawing the diagram the way you did. **(2 marks)**