1. Given the following reaction:

$$2NaOCl_{(aq)} \longrightarrow 2NaCl_{(aq)} + O_{2(g)}$$
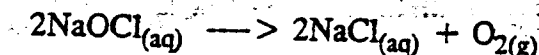
The catalyst $Co_2O_{3(s)}$ is added to the above reaction and the system is closed. Which of the following properties could be monitored in order to determine reaction rate?
- (A) Pressure.
- B. Mass of Co_2O_3.
- C. Concentration of Na^+.
- D. Concentration of Co_2O_3.

2. The following equation represents the reaction between copper metal and aqueous silver nitrate solution:

$$Cu_{(s)} + 2AgNO_{3(aq)} \longrightarrow Cu(NO_3)_{2(aq)} + 2Ag_{(s)}$$

brown   colourless   blue   grey
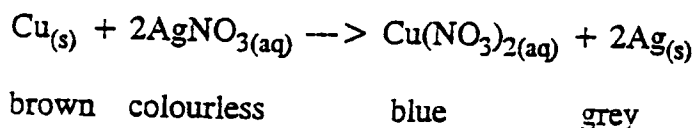
Which of the following properties would **best** monitor the rate of this reaction?
- A. Concentration of NO_3^-
- B. Gas pressure.
- (C) Colour of solution.
- D. Mass of the system.

3. Which of the following quantities, when graphed, can be used to determine a reaction rate?
- A. Colour vs. density.
- (B) Gas volume vs. time.
- C. Pressure vs. temperature.
- D. Mass vs. activation energy.

4. Which of the following reactions would be expected to have the fastest rate at room temperature?
- A. $Hg_{(l)} + Br_{2(l)} \longrightarrow HgBr_{2(g)}$
- B. $2H_{2(g)} + O_{2(g)} \longrightarrow 2H_2O_{(g)}$
- (C) $Ag^+_{(aq)} + Cl^-_{(aq)} \longrightarrow AgCl_{(s)}$
- D. $4NH_{3(g)} + 7O_{2(g)} \longrightarrow 4NO_{2(g)} + 6H_2O_{(g)}$

5. Which of the following reactions is **MOST LIKELY** to have the greatest rate at room temperature?
- (A) $Pb^{2+}_{(aq)} + 2Cl^-_{(aq)} \longrightarrow PbCl_{2(s)}$
- B. $H_{2(g)} + Cl_{2(g)} \longrightarrow 2HCl_{(g)}$
- C. $C_2H_{4(g)} + 3O_{2(g)} \longrightarrow 2CO_{2(g)} + 2H_2O_{(g)}$
- D. $Zn_{(s)} + S_{(s)} \longrightarrow ZnS_{(s)}$

6. Which one of the following reactions would be expected to proceed at the greatest rate at room temperature?
- A. $Mg_{(s)} + \frac{1}{2}O_{2(g)} \longrightarrow MgO_{(s)}$
- B. $Br_{2(g)} + Cl_{2(g)} \longrightarrow 2BrCl_{(g)}$
- (C) $2Ag^+ + CrO_4^{2-} \longrightarrow Ag_2CrO_4$
- D. $2BrO_3^- + 10 Fe^{2+} + 12 H^+ \longrightarrow 10 Fe^{3+} + Br_2 + 6 H_2O$

7. Increasing temperature results in an increase in reaction rate. This is due to
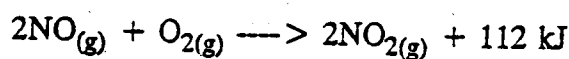- A. an increase in ΔH.
- B. an alternate reaction path.
- C. a decrease in activation energy.
- (D) an increase in the fraction of particles possessing sufficient energy.

8. Consider the following reaction:

$$Zn_{(s)} + 2HCl_{(aq)} \longrightarrow ZnCl_{2(aq)} + H_{2(g)}$$
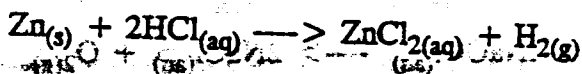
The rate of the above reation is dependent on
- A. temperature only.
- B. surface area only.
- (C) temperature and surface area.
- D. temperature, surface area, and pressure.

9. Which factor(s) affects the rate of a homogeneous reaction?
- A. Concentration only.
- (B) Temperature and concentration.
- C. Temperature and surface area.
- D. Temperature, concentration, and surface area.
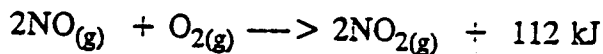
10. Consider the following reaction:

$$2NO_{(g)} + O_{2(g)} \longrightarrow 2NO_{2(g)} + 112 \text{ kJ}$$

The rate of the above reaction could be increased by
- (A) an increase in [NO].
- B. a decrease in pressure.
- C. a decrease in temperature.
- D. an increase in surface area.

11. Consider the following reaction occurring in a closed container:

$$Br_{2(g)} + Cl_{2(g)} \longrightarrow 2BrCl_{(g)} \quad \Delta H = -61 \text{ kJ}$$
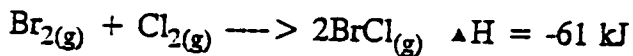
Which change will increase the frequency of effective collisions between Br_2 and Cl_2 molecules?
- A. Remove some BrCl.
- B. Decrease the pressure.
- (C) Increase the temperature.
- D. Increase the container volume.

12. An increase in concentration of a reactant increases reaction rate. This increase in reaction rate is due to
- A. an increase in ΔH.
- B. an increase in kinetic energy.
- C. a decrease in activation energy.
- (D) an increase in frequency of successful collisions.

13. Consider the following reaction:

$$2NO_{(g)} + O_{2(g)} \longrightarrow 2NO_{2(g)} + 112 \text{ kJ}$$

The rate of the above reaction could be decreased by
- A. an increase in [NO].
- (B) a decrease in pressure.
- C. an increase in temperature.
- D. a decrease in surface area.

14. One way of increasing the rate of a reaction is to
- A. increase the activation energy of the reaction.
- (B) increase the frequency of collisions of reactant molecules.
- C. decrease the overall enthalpy change of the reaction.
- D. increase the potential energy of the activated complex.

2

15. Which would be the best procedure to use to increase the rate of the following reaction?

$$PCl_{5(g)} \longrightarrow PCl_{3(g)} + Cl_{2(g)}$$
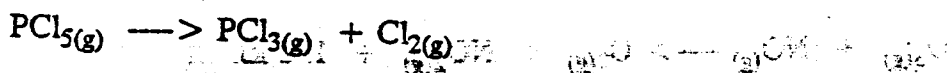
    A. Increase surface area.
    B. Increase temperature.
   C. Decrease temperature.
    D. Decrease pressure.

16. When reacting zinc with sulphuric acid, which experimental conditions would be expected to result in the greatest rate?
    A. 0.50 M H_2SO_4, powdered Zn, 50°C.
    B. 1.0 M H_2SO_4, powdered Zn, 50°C.
    C. 1.0 M H_2SO_4, block of Zn, 50°C.
    D. 1.0 M H_2SO_4, powdered Zn, 25°C.

17. If all other factors were equal, what effect would a decrease in activation energy have on the reaction rate?
    A. Increase the rate.
    B. Decrease the rate.
    C. No effect on the rate.
    D. Drop the rate to zero.

18. Consider this reaction:

$$H_{2(g)} + I_{2(g)} \longrightarrow 2HI_{(g)}$$
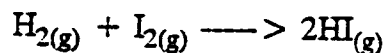
What happens to the potential energy and the kinetic energy as a molecule of H_2 approaches a molecule of I_2?
    A. The PE and the KE increase.
    B. The PE and the KE decrease.
    C. The PE increases and the KE decreases.
    D. The PE decreases and the KE increases.

19. A solution of acid is added to a solution of base, resulting in an increase in temperature. This result indicates that the acid-base reaction is
    A. exothermic and ▲H is positive.
    B. exothermic and ▲H is negative.
    C. endothermic and ▲H is positive.
    D. endothermic and ▲H is negative.

20. A two-step reaction mechanism has at least
    A. one reaction intermediate and one activated complex.
    B. two reaction intermediates and one activated complex.
    C. one reaction intermediate and two activated complexes.
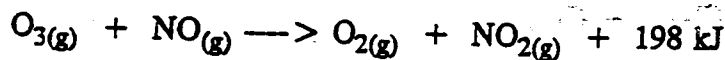   D. two reaction intermediates and two activated complexes.

21. The activation energy of a reaction is determined by the
    A. nature of reactants.
    B. temperature of reactants.
    C. surface area of reactants.
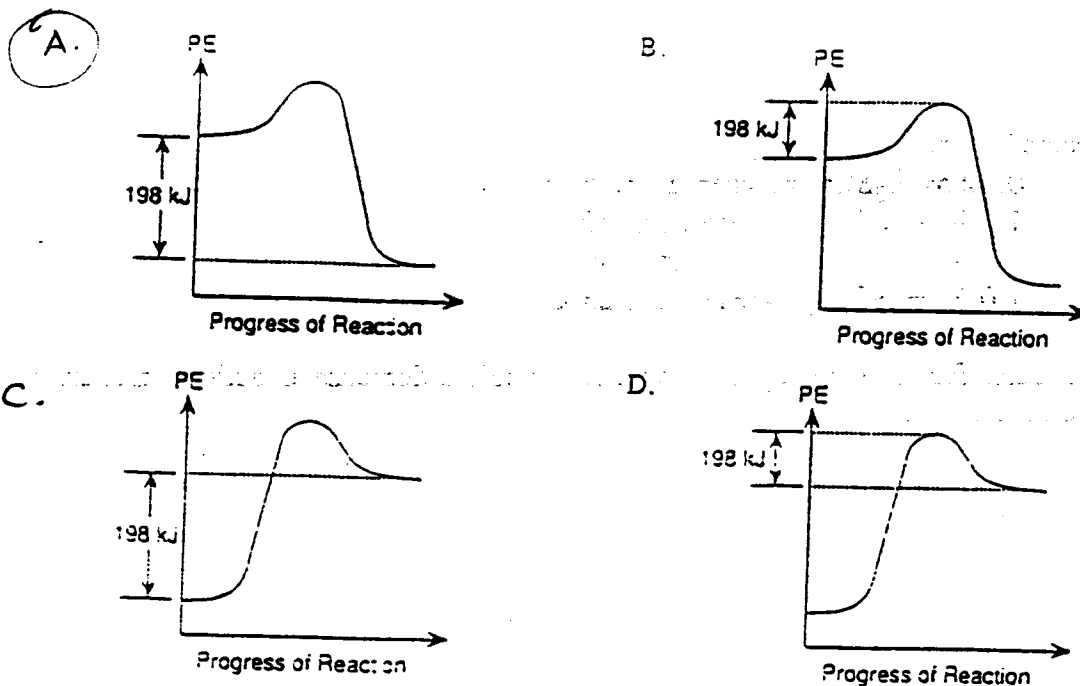   D. concentration of reactants.

22. An activated complex may be described as a molecular species which is
    A. long-lived and has low PE.
    B. short-lived and has low PE.
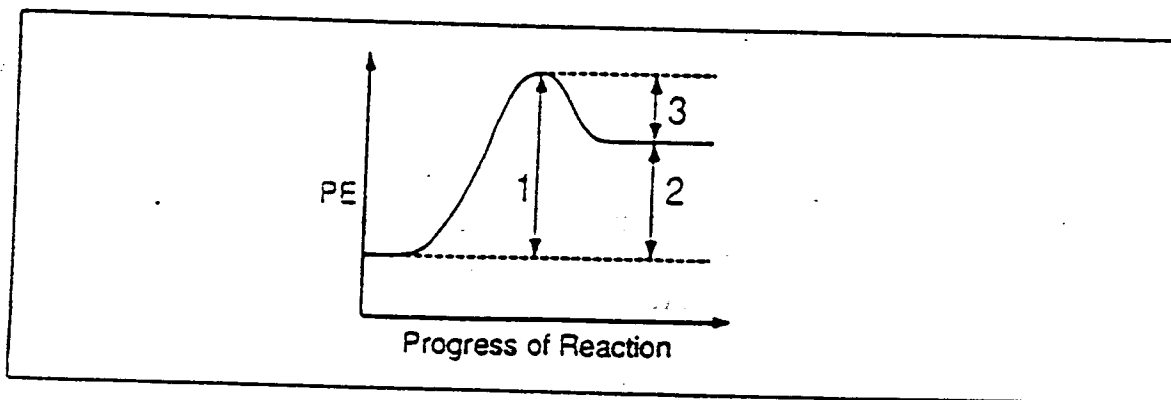   C. short-lived and has high PE.
    D. long-lived and has high PE.

23. Consider this reaction:

$$O_{3(g)} + NO_{(g)} \longrightarrow O_{2(g)} + NO_{2(g)} + 198 \text{ kJ}$$

The energy diagram which best describes this reaction is

A.

198 kJ

Progress of Reaction

B.

198 kJ

Progress of Reaction

C.

198 kJ

Progress of Reaction

D.

198 kJ

Progress of Reaction

Use the following diagram to answer question 24.

PE | 1 | 3 | 2

Progress of Reaction

24. Consider the above potential energy diagram. The intervals which represent ▲H and the activation energy of the forward reaction are
   A.   ▲H is interval 1 and activation energy is interval 3.
   B.   ▲H is interval 1 and activation energy is interval 2.
   C.   ▲H is interval 2 and activation energy is interval 3.
   D.   ▲H is interval 2 and activation energy is interval 1.

25. Which statement is true about the activated complex?
   A.   It acts as a catalyst.
   B.   It is a stable compound.
   C.   It always forms products.
   D.   It posesses more potential energy than the reatants or the products.
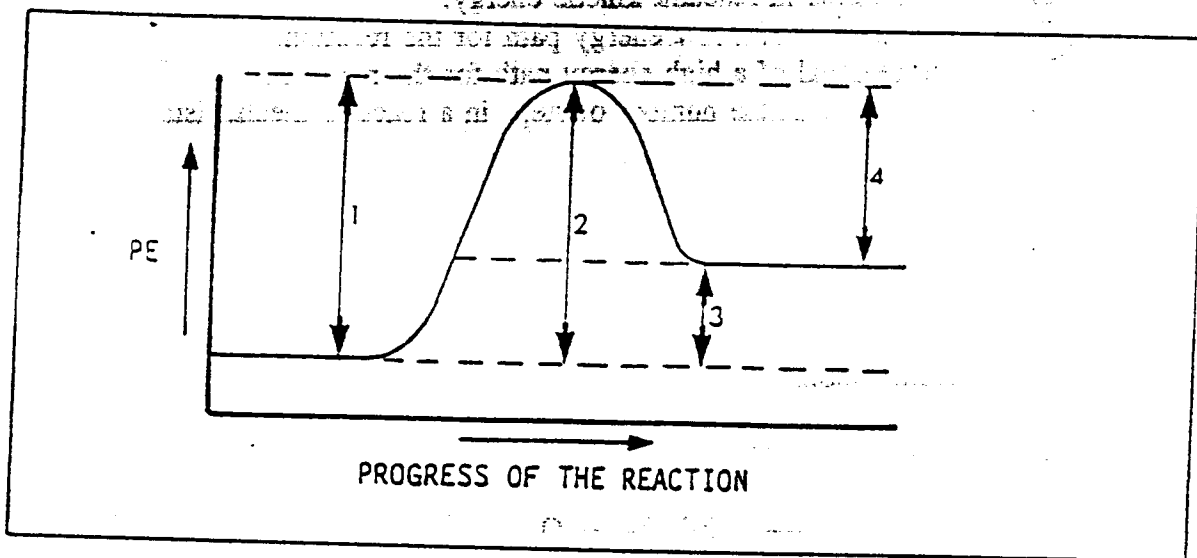
26. Which interval in the above potential energy diagram represents the ΔH value for the reaction?
  A. 1
  B. 2
  C. 3
  D. 4

Use the following diagram to answer questions 27 and 28.
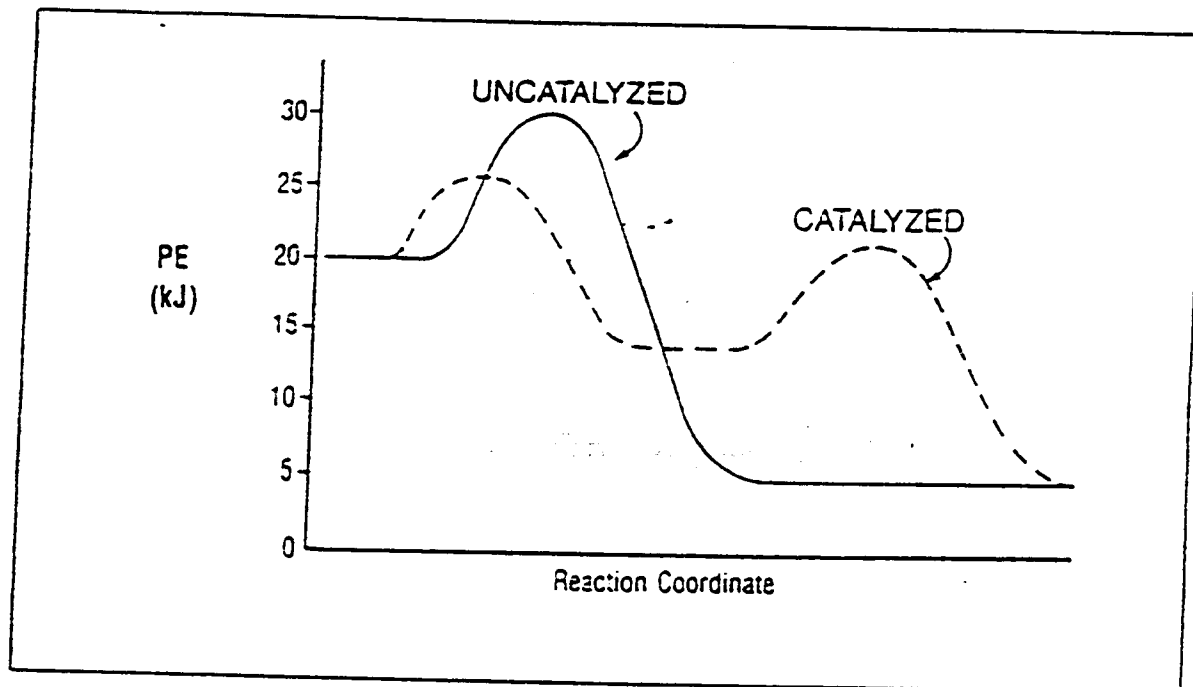
27. Given the above potential energy diagram for a catalyzed and uncatalyzed reaction, the ΔH for the forward catalyzed reaction is
  A. -20 kJ
  B. -15 kJ
  C. 5 kJ
  D. 15 kJ

28. The activation energy for the forward uncatalyzed reaction is
 A. 10 kJ
  B. 15 kJ
  C. 25 kJ
  D. 30 kJ

29. The effect of a catalyst is thought to be due to
   A.   an increase in reactant kinetic energy.
   B.   the addition of a low energy path for the reaction.
   C.   the removal of a high energy path for the reaction.
   D.   a decrease in the number of steps in a reaction mechanism.

30. Which of the following is a common commercial catalyst?
   A.   Octane.
   B.   Krypton.
   C.   Platinum.
   D.   Hemoglobin.

31. Consider the following equation:

$$2H_2O_{2(aq)} \longrightarrow 2H_2O_{(l)} + O_{2(g)}$$
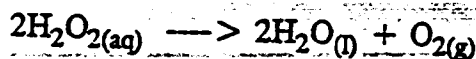
When a piece of raw potato was added to the above reaction, the reaction rate increased dramatically. An enzyme in the potato was found to be responsible for the increase in the reaction rate. In this reaction, the enzyme would be referred to as
   A.   a catalyst.
   B.   an inhibitor.
   C.   an activated complex.
   D.   a reaction intermediate.

32. Which statement is true about what occurs after a catalyst has been added to a system?
   A.   The forward reaction rate only will increase.
   B.   The reverse reaction rate only will increase.
   C.   The forward and reverse reactions will both increase.
   D.   The forward and reverse reaction rates will both remain unchanged.

33. A reaction mechanism is
   A.   the order in which the chemicals are mixed together.
   B.   the experimental apparatus used for a chemical reaction.
   C.   the combination of reactants used to carry out a reaction.
   D.   the series of collisions resulting in the overall reaction.

34. Which step in a reaction mechanism determines the rate?
   A.   The last step.
   B.   The first step.
   C.   The fastest step.
   D.   The slowest step.
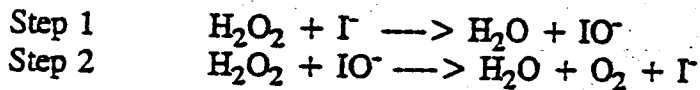
35. Use the following reaction to answer this question:

   A + B ---> C
   C + K ---> D + A
   D ---> M + N
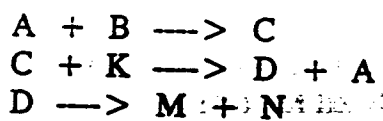
In the above reaction mechanism, which species is acting as a catalyst?
   A.   A
   B.   B
   C.   C
   D.   D

36. Consider this two-step reaction mechanism:

Step 1 $H_2O_2 + I^- \longrightarrow H_2O + IO^-$
Step 2 $H_2O_2 + IO^- \longrightarrow H_2O + O_2 + I^-$

The reaction intermediate is
A. I^-
B. O_2
C. IO^-
D. H_2O

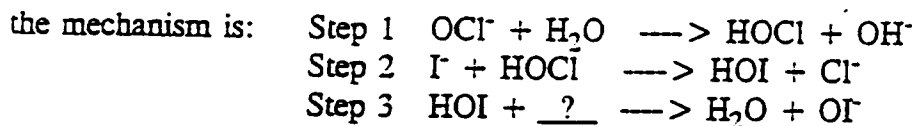Use the three-step reaction mechanism below to answer questions 37 and 38.

step 1: $N_2 + 2O_2 \longrightarrow 2NO_2$
step 2: $2NO_2 \longrightarrow NO_3 + NO$
step 3: $NO_3 + CO \longrightarrow NO_2 + CO_2$
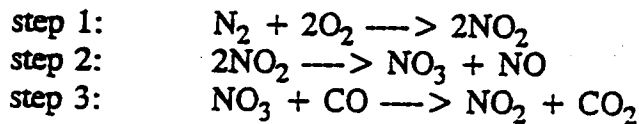
37. A reaction intermediate is
A. O_2
B. NO
C. CO
D. NO_3

38. The overall reaction from the three steps shown above is
A. $CO + NO_3 \longrightarrow CO_2 + NO_2$
B. $N_2 + O_2 + CO \longrightarrow NO + NO_2 + CO_2$
C. $N_2 + 2O_2 + CO \longrightarrow NO + NO_2 + CO_2$
D. $N_2 + O_2 + CO_2 + NO_2 \longrightarrow NO + 2NO_2 + CO_2$

39. For the overall reaction $OCl^- + I^- \longrightarrow OI^- + Cl^-$

the mechanism is: Step 1 $OCl^- + H_2O \longrightarrow HOCl + OH^-$
                      Step 2 $I^- + HOCl \longrightarrow HOI + Cl^-$
                      Step 3 $HOI + \underline{\ \ ?\ \ } \longrightarrow H_2O + OI^-$

The missing particle in step 3 is
A. Cl^-
B. OH^-
C. OCl^-
D. $HOCl$

40. The reaction $2A + B + C \longrightarrow D$ takes place through the following mechanism in which I_1 and I_2 represent reaction intermediates.

Step 1 (slow) $A + B \longrightarrow I_1$
Step 2 (fast) $I_1 + A \longrightarrow I_2$
Step 3 (fast) $I_2 + C \longrightarrow D$
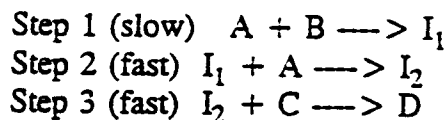
How can you produce a significant increase in the rate of the overall reaction?
A. Increase [B].
B. Decrease [B].
C. Increase [C].
D. Decrease [A].