1a) For the following reaction at equilibrium, which of the following disturbances will increase product yield?

$2H_2S(g) + O_2(g) \rightleftarrows 2S(s) + 2H_2O(g)$, $\Delta H°_{rxn} = +30$ kJ $K_p = 2.6x10^{-9}$ at 25°C

I: Increase temperature II: Increase volume III: decreasing moles of O_2

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

1b) Fill in the blank

The principle used in part 1a to determine the shift in an equilibrium reaction is called _____

2) Consider the following overall reaction and its rate law: 2 A + B → 2 C, Rate = k [A][B]. Which of the following mechanisms can be considered a possible mechanism for the reaction?

I: 2 A + B → 2 C (one step)

II: A + B ⇄ M (slow)
M+ A → 2 C (fast)

III: A + B ⇄ M (fast)
M+ A → 2 C (slow)

A) Only I
B) Only II
C) I and III
D) II and III
E) I, II, and III

Use the following two reactions for questions 3-4:

$A_{(s)} + B_{(g)} \rightarrow C_{(g)} + 2D_{(g)}$ $K_p = 1.0 \times 10^{-2}$

$2D_{(g)} \rightarrow E_{(g)} + F_{(g)}$ $K_p = 1 \times 10^{1}$

3) What is the K_p of the following reaction? Be sure to show all your work to be eligible for partial credit.

$2A_{(s)} + 2B_{(g)} \rightarrow 2C_{(g)} + 2D_{(g)} + E_{(g)} + F_{(g)}$

4) If excess A and 10.0 atm of B react according to reaction 1, what would be the predicted partial pressure of D at equilibrium?

A) 0.37 atm
B) 0.58 atm
C) 0.29 atm
D) 0.16 atm
E) 0.32 atm

5) Which of the following statements is *false*? Then, correct the false statement.

A) Increasing the temperature increases the rate of a reaction
B) Increasing the temperature increases the rate constant of a reaction
C) The activation energy is the energy difference between reactants and products
D) Lowering the activation energy increases the rate of a reaction.

6) The decomposition of N_2O_4 into NO_2 has $K_p = 2$. Some N_2O_4 is placed into an empty container, and the partial pressure of NO_2 at equilibrium is measured to be 0.2 atm. What was the initial pressure in the container prior to decomposition?

A) 0.12 atm
B) 0.10 atm
C) 0.20 atm
D) 0.22 atm
E) 0.30 atm

Consider the following reactions when answering questions 7-8.
Reaction 1: $2NO(g) + Br_2(g) \rightleftarrows 2NOBr(g)$ $\Delta H°_{rxn} = -16$ kJ $K_p = 27$ at 25°C
Reaction 2: $CO_2(g) \rightleftarrows C(s) + O_2(g)$ $\Delta H°_{rxn} = +100$ kJ $K_p = 2.6 \times 10^{-9}$ at 25°C

7) For which reaction(s) above would an increase in reaction vessel volume at constant temperature result in an increase in product yield?
A) Neither Reaction
B) Reaction 1 only
C) Reaction 2 only
D) Both reactions

8) For which reaction(s) above would an increase in temperature at constant volume result in an increase in product yield?
A) Neither Reaction
B) Reaction 1 only
C) Reaction 2 only
D) Both reactions

9) The equilibrium constant K_c is found to be 1.05 for the decomposition of phosphorus pentachloride to phosphorus trichloride and molecular chlorine at 250 °C. If the initial concentrations of PCl_5, PCl_3, and Cl_2 are 0 M, 3 M, and 4 M, respectively, what is the equilibrium concentration of PCl_3 at 250 °C? $PCl_{5(g)} \rightleftarrows PCl_{3(g)} + Cl_{2(g)}$. Show your work.

10) Sodium-24 is a radioactive isotope that decays via first order kinetics and has a half-life of 15 hours. What fraction of an original sample of sodium-24 will decompose in 3 days?

A) 4% B) 13% C) 50% D) 87% E) 96%

11) For the following reaction, given that a 1L flask initially contains 2 moles S_8, 2 moles SF_6, and 2 moles F_2, will Q or k be larger? Will the reaction shift towards the products or the reactants? Show your work.

$1/8\ S_8\,(s) + 3\ F_2\,(g) \rightleftarrows SF_6\,(g) \quad K_c = 0.425$

12) Given the overall reaction $2H_2 + 2NO \rightarrow 2H_2O + N_2$ and the following mechanism:

Step 1: $NO + NO \rightleftharpoons N_2O_2$ (fast)

Step 2: $N_2O_2 + H_2 \rightarrow H_2O + N_2O$ (slow)

Step 3: $N_2O + H_2 \rightarrow N_2 + H_2O$ (fast)

Which of the following is/are true?

I: The rate law for the overall reaction is Rate = $k[N_2O_2][H_2]$

II: The absolute value of the rate of change of H_2 is ½ the rate of change of N_2

III: The rate of the reaction is equal to the rate of H_2

A) Only I B) Only II C) Only III D) I, II, and III E) None

13) Given the following experimental data, find the rate law and the rate constant. Show all work to be eligible for partial credit.

$4A_{(g)} + 3B_{(g)} \rightarrow 2C_{(g)}$

Experiment	Initial [A] (M)	Initial [B] (M)	Initial Rate (M/min)
1	0.100	0.100	5.00
2	0.300	0.100	45.0
3	0.100	0.200	10.0
4	0.300	0.200	90.0

14) The rate constant of a reaction is $4.7 \times 10^{-3}\ s^{-1}$ at 25°C, and the activation energy is 33.6 kJ/mol. What is k at 75°C?

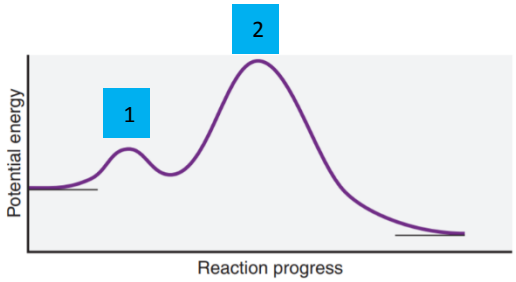
15) In a study of nitrosyl halides, a chemist proposes the following mechanism for the synthesis of nitrosyl bromide:

$NO_{(g)} + Br_{2(g)} \rightarrow NOBr_{2(g)}$ [fast, equilibrium]

$NOBr_{2(g)} + NO_{(g)} \rightarrow 2NOBr_{(g)}$ [slow]

If the rate law is rate=$k[NO]^2[Br_2]$, is the proposed mechanism valid? Show all your work.

16)



a) Free response: How many elementary steps are in the reaction mechanism?

b) Which step is rate limiting? 1 or 2

c) Is the overall reaction exothermic or endothermic? Exothermic/Endothermic

17) What is the k_b of a conjugate base if the k_a of the acid is 7.1×10^{-4} ? Show your work.