

How all work in the question booklet.

1. Which of the following applies to a chemical equilibrium:

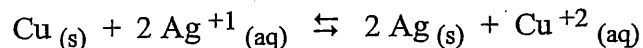
- I. Forward reaction rate = reverse reaction rate
- II. Equilibrium can be achieved in either direction.
- III. Macroscopic properties are constant.
- IV. $[Reactant] = [Product]$

- A. I and IV only
- B. II and III only
- C. I, II and IV only
- D. I, II and III only

2. Which of the factors below is **not** a condition necessary for equilibrium?

- A. equal forward and reverse reaction rates
- B. a closed system
- C. equal concentrations of reactants and products
- D. a constant temperature

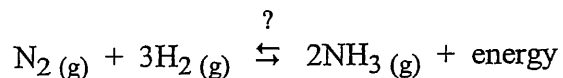
3. For the equilibrium system below:



We would know the system is at equilibrium because

- A. the mass of Cu (s) remains constant
- B. the mass of the entire system remains constant
- C. $[\text{Cu}^{+2}] = [\text{Ag}^{+1}]$
- D. $[\text{Cu}^{+2}] = 2[\text{Ag}^{+1}]$

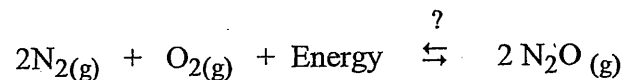
4. Consider the following:



What positions do minimum enthalpy and maximum entropy tend towards?

- | | |
|------------------|-----------------|
| Minimum Enthalpy | Maximum Entropy |
| A. products | products |

5. Consider the following:



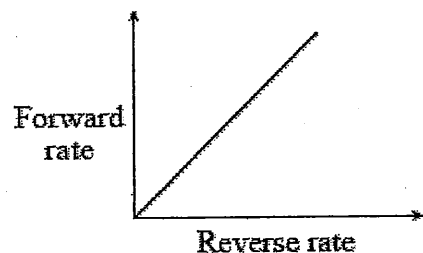
What positions to minimum enthalpy and maximum entropy tend towards?

Minimum Enthalpy Maximum Entropy

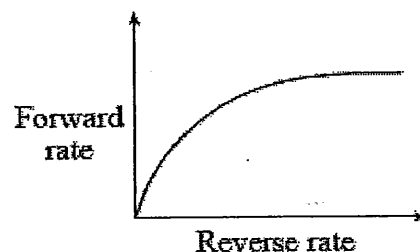
- | | | |
|----|-----------|-----------|
| A. | products | products |
| B. | reactants | products |
| C. | reactants | reactants |
| D. | products | reactants |

6. At different conditions, the relationship between the forward and reverse rates of reactions in an equilibrium system can be best represented by:

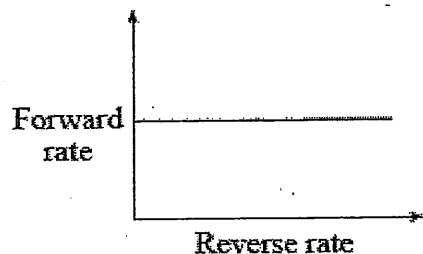
A.



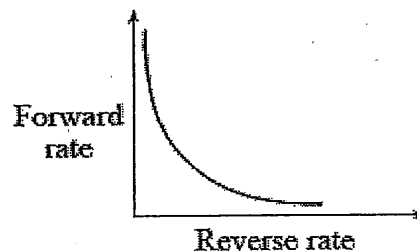
B.



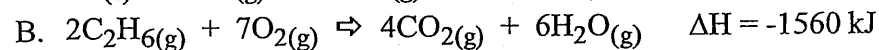
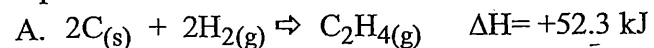
C.



D.



7. In which of the following will entropy and enthalpy factors favour the establishment of an equilibrium?



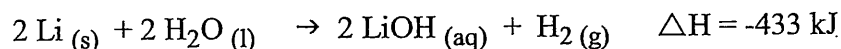
9. In which of the following will the driving forces of minimum enthalpy and maximum entropy oppose one another?

- A. $4\text{CO}_2(\text{g}) + 6\text{H}_2\text{O}(\text{g}) \rightarrow 2\text{C}_2\text{H}_6(\text{g}) + 7\text{O}_2(\text{g})$ $\Delta H = +3122 \text{ kJ}$ *change to +1560*
- B. $2\text{CO}(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g})$ $\Delta H = -566 \text{ kJ}$
- C. $2\text{C}(\text{s}) + \text{O}_2(\text{g}) \rightarrow \text{CO}_2(\text{g})$ $\Delta H = -221 \text{ kJ}$
- D. $2\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{N}_2\text{O}(\text{g})$ $\Delta H = +164 \text{ kJ}$

10. In order for a chemical reaction to go to completion, how must the entropy and enthalpy change?

- | | Entropy | Enthalpy |
|----|-----------|-----------|
| A. | decreases | increases |
| B. | increases | decreases |
| C. | increases | increases |
| D. | decreases | decreases |

11. For the reacting system:



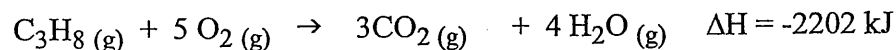
What will entropy and enthalpy factors favor?

- | | Entropy | Enthalpy |
|----|-----------|-----------|
| A. | reactants | products |
| B. | reactants | reactants |
| C. | products | products |
| D. | products | reactants |

12. Which of the following reactions is accompanied by an increase in enthalpy?

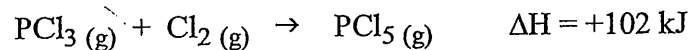
- A. $4\text{HCl}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{H}_2\text{O}(\text{g}) + 2\text{Cl}_2(\text{g}) \quad \Delta H = -111.4 \text{ kJ}$
- B. $2\text{SO}_3(\text{g}) \rightleftharpoons 2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \quad \Delta H = +197 \text{ kJ}$
- C. $2\text{NO}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g}) + 113 \text{ kJ}$
- D. $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) - 484 \text{ kJ} \rightleftharpoons 2\text{H}_2\text{O}(\text{g})$

13. Consider the following reaction:



Which of the following applies to the forward reaction?

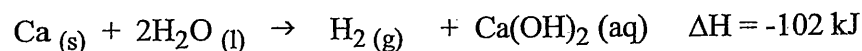
14. Consider the following reaction:



Which of the following applies to the forward reaction?

- | | Entropy | Enthalpy |
|----|-----------|-----------|
| A. | decreases | decreases |
| B. | decreases | increases |
| C. | increases | increases |
| D. | increases | decreases |

15. Consider the following reaction:



Which of the following applies to the forward reaction?

- | | Entropy | Enthalpy |
|----|-----------|-----------|
| A. | decreases | decreases |
| B. | decreases | increases |
| C. | increases | increases |
| D. | increases | decreases |

16. Two substances are mixed and no reaction occurs. With respect to enthalpy and entropy, which of the following could explain why no reaction occurs?

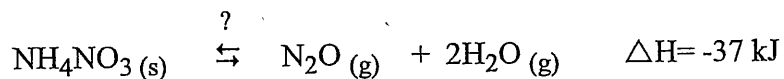
- | | Enthalpy | Entropy |
|----|-----------|-----------|
| A. | decreases | increases |
| B. | decreases | decreases |
| C. | increases | decreases |
| D. | increases | increases |

17. Which of the following forward reaction changes would result in the most products?

- | | Entropy | Enthalpy |
|----|------------|------------|
| A. | decreasing | increasing |
| B. | increasing | increasing |
| C. | increasing | decreasing |
| D. | decreasing | decreasing |

18. In which of the following reactions do the tendencies for minimum enthalpy and maximum

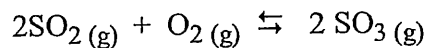
19. Consider the following equation:



Which of the following is true?

Enthalpy	Entropy	Outcome
A. favours products	favours products	reaction goes to completion
B. favours products	favours reactants	reaction reaches equilibrium
C. favours reactants	favours reactants	reaction does not occur
D. favours reactants	favours products	reaction reaches equilibrium

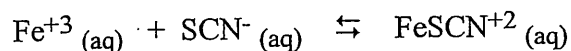
20. Consider the following:



Initially, SO_3 is added to an empty flask. How do the rate of the reverse reaction and $[\text{SO}_3]$ change as the system proceeds to equilibrium?

Reverse Rate	$[\text{SO}_3]$
A. decreases	decreases
B. increases	decreases
C. decreases	increases
D. increases	increases

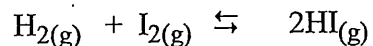
21. Some Fe^{+3} and SCN^- were mixed and established the following equilibrium:



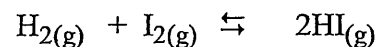
What happened to the forward rate and the $[\text{Fe}^{+3}]$ as equilibrium was established?

forward rate	$[\text{Fe}^{+3}]$
A. decreased	decreased
B. increased	decreased
C. decreased	increased
D. increased	increased

22. Consider the following equilibrium:



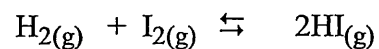
23. Consider the following equilibrium:



How will the forward and reverse equilibrium reaction rates change when H_2 is removed from the system?

- | | Forward rate | Reverse rate |
|----|--------------|--------------|
| A. | increase | increase |
| B. | decrease | increase |
| C. | decrease | decrease |
| D. | increase | decrease |

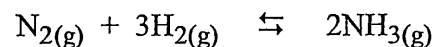
24. Consider the following equilibrium:



How will the forward and reverse equilibrium reaction rates change when the temperature is lowered within the system?

- | | Forward rate | Reverse rate |
|----|--------------|--------------|
| A. | increase | increase |
| B. | decrease | increase |
| C. | decrease | decrease |
| D. | increase | decrease |

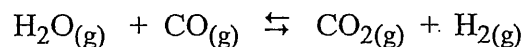
25. Consider the following equilibrium:



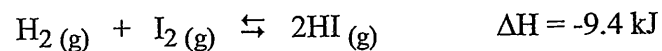
Which of the following factors will **not** alter the position of equilibrium?

- A. a temperature increase
- B. the addition of more $\text{N}_2(\text{g})$
- C. a pressure decrease
- D. addition of a catalyst

26. Consider the following system at equilibrium:



27. Consider the following equilibrium system:



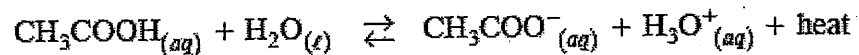
In an experiment, the equilibrium concentrations of the chemical species were measured before and after a stress was added. The results are displayed:

Chemical species	[] before stress was applied	[] after stress was applied
H ₂	0.050 M	0.070 M
I ₂	0.050 M	0.070 M
HI	0.40 M	0.56 M

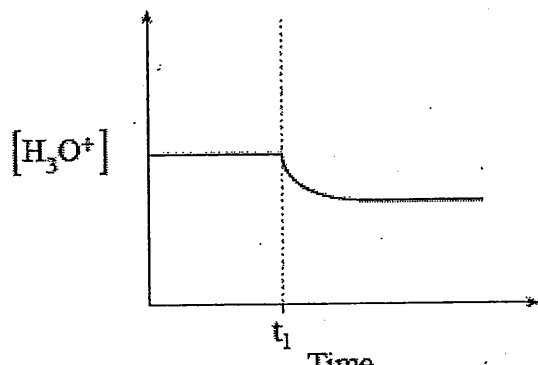
Which one of the following stresses would be consistent with the above data?

- A. a decrease in pressure
- B. an increase in temperature
- C. the addition of H₂
- D. the addition of HI

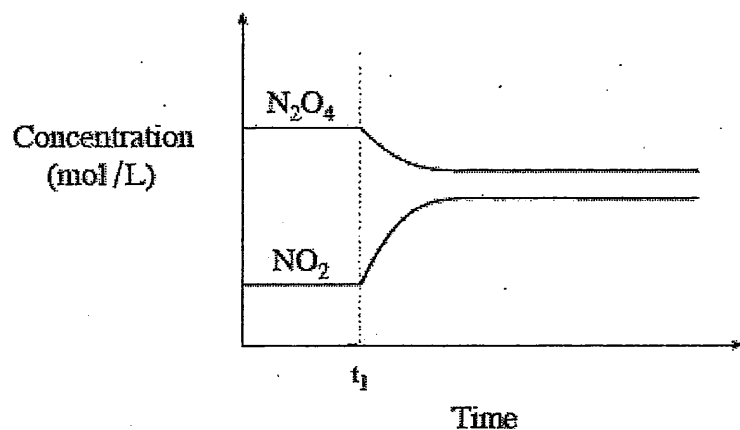
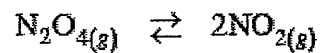
28. Consider the following equilibrium:



A stress was applied at time t_1 and the data was plotted on the following graph:



29. Consider the following equilibrium reaction:

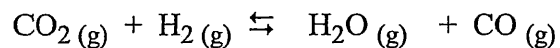


At time t_1 , heat is applied to the system. Which of the following best describes the equilibrium reaction and the change in K_{eq} ?

Move to after 52!

- | Forward reaction | K_{eq} |
|------------------|-----------|
| A. endothermic | decreases |
| B. endothermic | increases |
| C. exothermic | increases |
| D. exothermic | decreases |

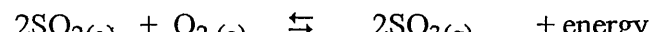
30. Consider the following equilibrium:



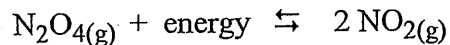
Which two stresses will cause the equilibrium to shift to the left?

- | | |
|---|---|
| A. decrease $[\text{H}_2]$ and decrease $[\text{CO}]$ | B. decrease $[\text{H}_2]$ and increase $[\text{CO}]$ |
| C. increase $[\text{H}_2]$ and increase $[\text{CO}]$ | D. increase $[\text{H}_2]$ and decrease $[\text{CO}]$ |

31. Consider the following:

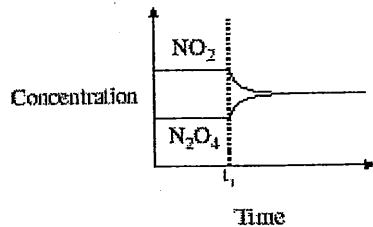


32. Consider the following equilibrium:

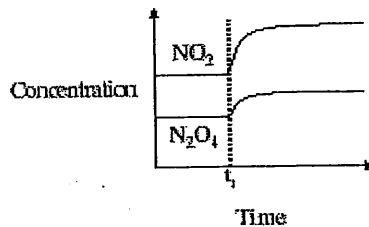


Which of the following graphs shows the result of adding a catalyst at time t_1 ?

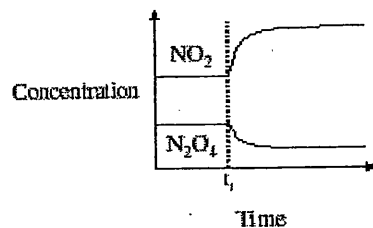
A.



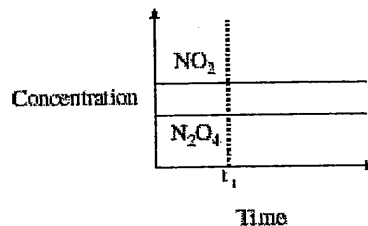
B.



C.



D.

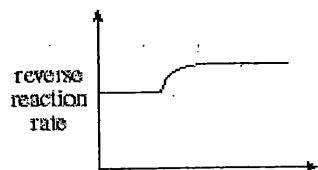


33. When the temperature of an exothermic equilibrium is decreased, which of the following will happen?

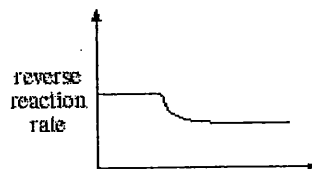
- A. Equilibrium shifts right and [reactant] increases
- B. Equilibrium shifts left and [product] decreases
- C. Equilibrium shifts left and [product] increases
- D. Equilibrium shifts right and [reactant] will decrease

34. Temperature is gradually decreased then held constant in an exothermic equilibrium. Which of the following represents the change in the reverse reaction rate?

A.



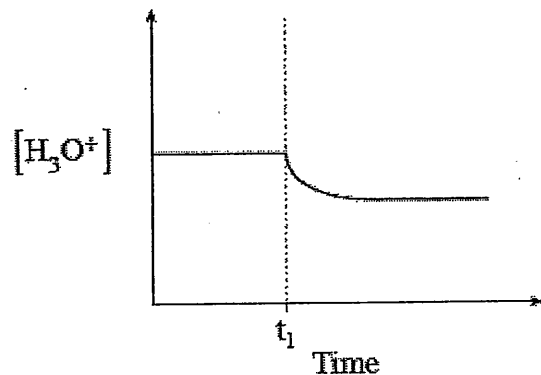
B.



35. Consider the following equilibrium:



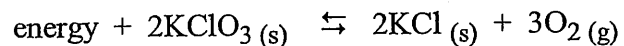
A stress was applied at time t_1 and the data was plotted on the following graph:



The stress that occurred at time = t_1 is a result of

- A. the addition of H_3O^+
- B. adding an inhibitor
- C. increasing the temperature
- D. the addition of H_2O

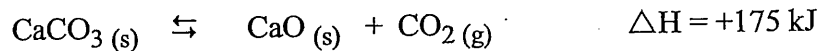
36. Consider the following equilibrium:



Which of the following will cause a shift to the left?

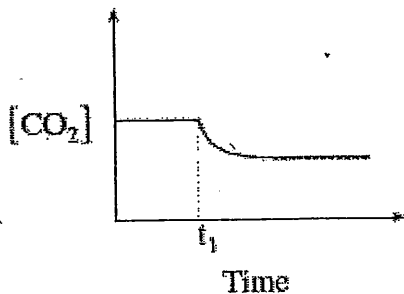
- A. increasing pressure
- B. increasing the temperature
- C. adding an inhibitor
- D. grinding up the KCl

37. Consider the following equilibrium:

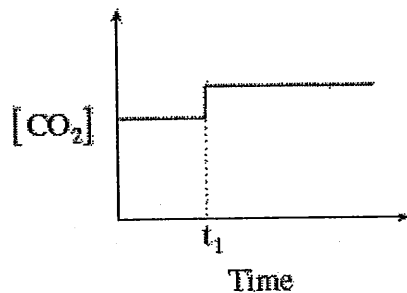


Which of the following diagrams best represents the change in the concentration of CO_2 as temperature is decreased at time t_1 ?

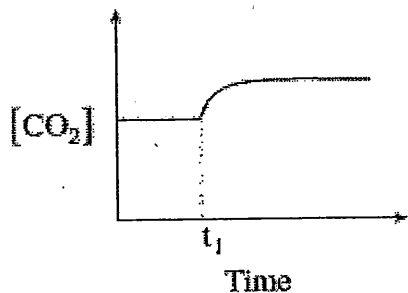
A.



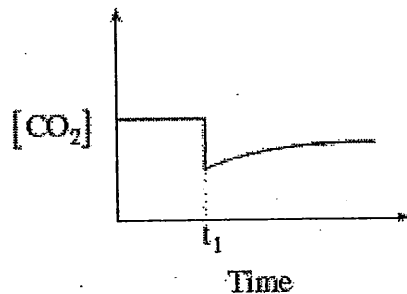
B.



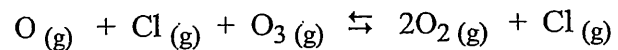
C.



D.



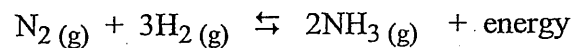
38. The following equation represents the catalyzed decomposition of O_3 (ozone):



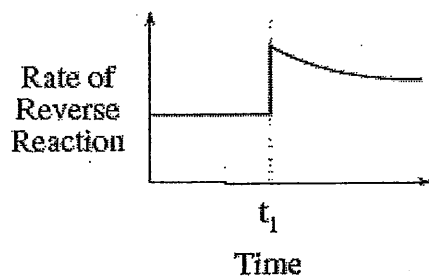
Which of the following statements is true?

- A. The catalyst O speeds up both the forward and reverse rates.
- B. The catalyst O speeds up only the forward rate.
- C. The catalyst Cl speeds up both the forward and reverse rates.
- D. The catalyst Cl speeds up only the forward rate.

39. Consider the following equilibrium:



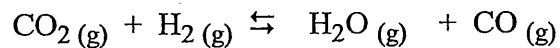
The following diagram represents the rate of the reverse reaction:



Which of the following stresses explains what happened at t_1 ?

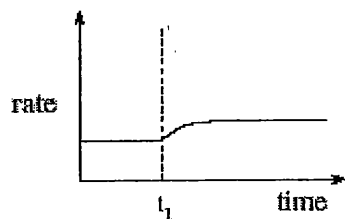
- A. $[\text{NH}_3]$ decreased
- B. $[\text{NH}_3]$ increased
- C. $[\text{H}_2]$ increased
- D. $[\text{N}_2]$ decreased

40. Consider the following equilibrium:

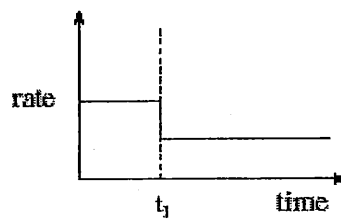


Which of the following graphs best represents the forward rate of reaction when H_2O is added to the above equilibrium at time = t_1 ?

A.



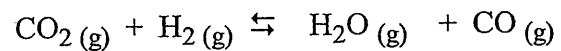
B.



C.

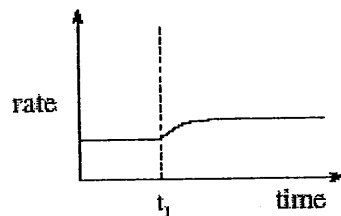
D.

41. Consider the following equilibrium:

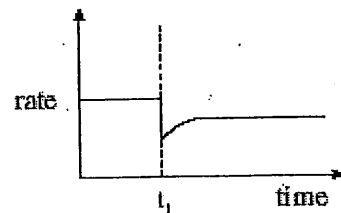


Which of the following graphs best represents the forward reaction rate when the volume of the container is increased at time = t_1 ?

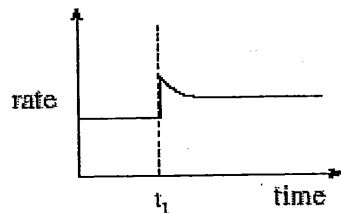
A.



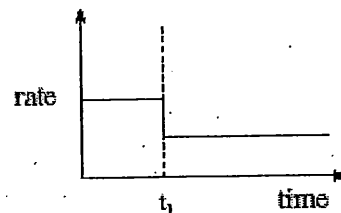
B.



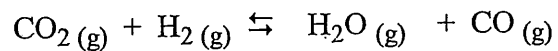
C.



D.

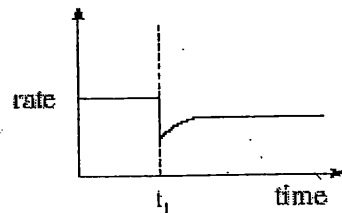


42. Consider the following equilibrium:

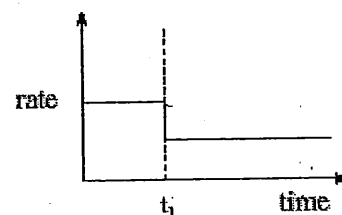


Which of the following graphs best represents the reverse reaction rate when some H_2O is removed from the above equilibrium at time = t_1 ?

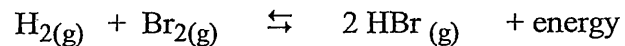
A.



B.

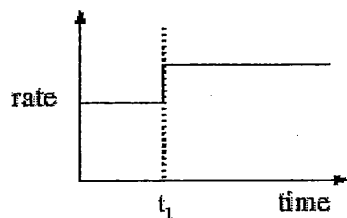


45. Consider the following equilibrium:

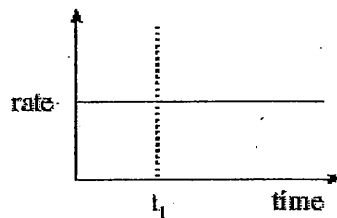


Which of the following shows the forward reaction rate when the volume of the container is increased at time = t_1 ?

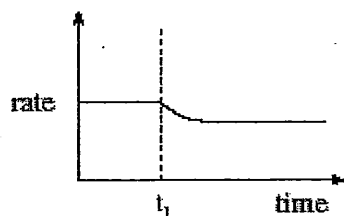
A.



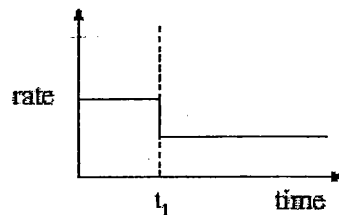
B.



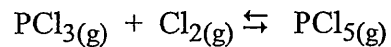
C.



D.



46. Consider the following equilibrium:

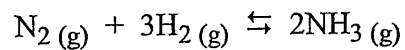


If the volume of the system is decreased, how will the reaction rates in the new equilibrium compare with the rates of the original equilibrium?

- | | Forward Rate | Reverse Rate |
|----|--------------|--------------|
| A. | decreases | decreases |
| B. | decreases | increases |
| C. | increases | increases |
| D. | increases | decreases |

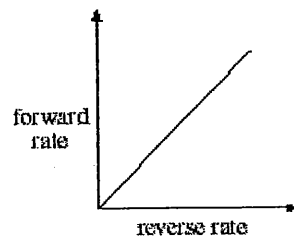
47. Consider the following equilibrium:

48. Consider the following reaction:

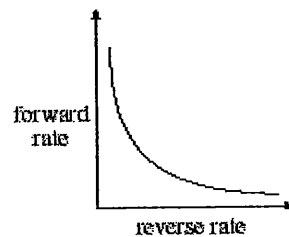


Which of the following diagrams represents what happens to the forward and reverse reaction rates when the catalyst Fe_3O_4 is added?

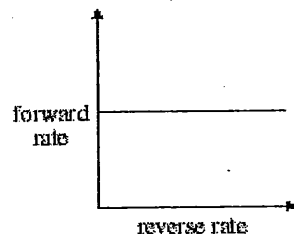
A.



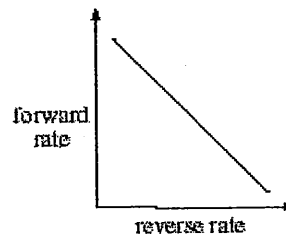
B.



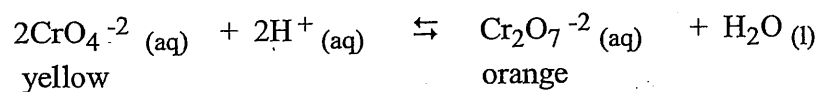
C.



D.



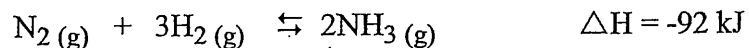
49. Consider the following equilibrium:



a. Is the forward reaction endothermic or exothermic? Explain.

b. When OH^- is added, the color of the solution turns from orange to yellow. Explain using LeChatelier's Principle.

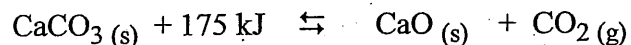
50. The Haber Process is used to produce ammonia commercially according to the following equilibrium:



Which of the following conditions will produce the highest yield of ammonia?

- A. decrease temperature and decrease pressure
- B. decrease temperature and increase pressure
- C. increase temperature and increase pressure
- D. increase temperature and decrease pressure

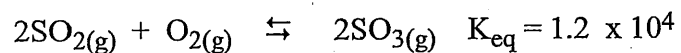
51. Limestone is decomposed to make quicklime (CaO) according to the following equilibrium:



Which of the following conditions would produce the greatest yield of CaO?

- | Temperature | Pressure |
|-------------|----------|
| A. high | low |
| B. high | high |
| C. low | low |
| D. low | high |

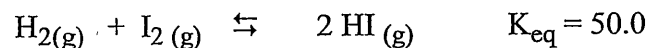
52. Consider the following equilibrium system:



If additional SO_2 is added the system, what happens to the equilibrium and the value of K_{eq} ?

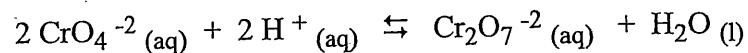
- | Equilibrium | K_{eq} |
|-----------------|-----------------|
| A. no change | no change |
| B. shifts right | no change |
| C. shifts left | decreases |
| D. shifts right | increases |

53. Consider the following equilibrium:



What is the value for K_{eq} for the same reaction rewritten as

54. Consider the following equilibrium:



What is the K_{eq} expression?

A.

$$\frac{[\text{Cr}_2\text{O}_7^{2-}]}{[2\text{CrO}_4^{2-}][2\text{H}^+]}$$

B.

$$\frac{[\text{Cr}_2\text{O}_7^{2-}][\text{H}_2\text{O}]}{[\text{CrO}_4^{2-}]^2[\text{H}^+]^2}$$

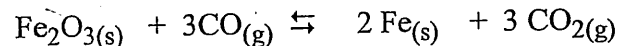
C.

$$\frac{[\text{CrO}_4^{2-}]^2[\text{H}^+]^2}{[\text{Cr}_2\text{O}_7^{2-}]}$$

D.

$$\frac{[\text{Cr}_2\text{O}_7^{2-}]}{[\text{CrO}_4^{2-}]^2[\text{H}^+]^2}$$

55. Consider the following equilibrium:



Identify the equilibrium constant expression.

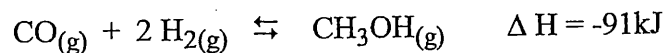
A. $K_{\text{eq}} = \frac{[3\text{CO}_2]^3 [2\text{Fe}]^2}{[3\text{CO}]^3 [\text{Fe}_2\text{O}_3]}$

B. $K_{\text{eq}} = \frac{[\text{CO}]^3 [\text{Fe}_2\text{O}_3]}{[\text{CO}_2]^3 [\text{Fe}]^2}$

C. $K_{\text{eq}} = \frac{[\text{CO}_2]^3}{[\text{CO}]^3}$

D. $K_{\text{eq}} = \frac{[3\text{CO}_2]}{[3\text{CO}]}$

56. Consider the following equilibrium:

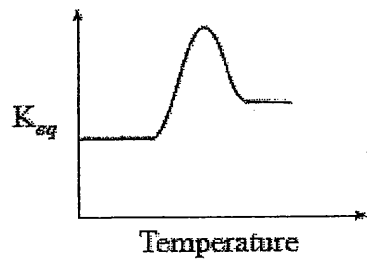


Which of the factors below would increase the concentration of the CH_3OH at equilibrium?

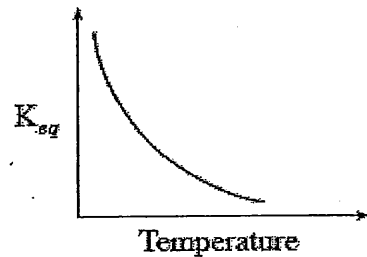
- A. a decrease in pressure
- B. an addition of CO
- C. an increase in temperature
- D. an increase in the volume

58. Which of the following best describes the relationship between K_{eq} and temperature for an endothermic forward reaction?

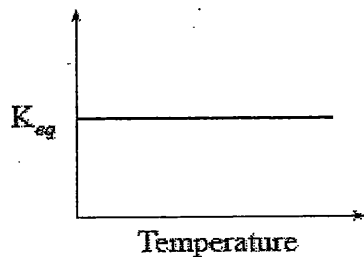
A.



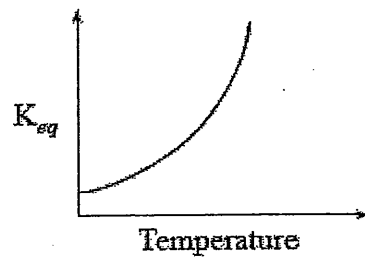
B.



C.

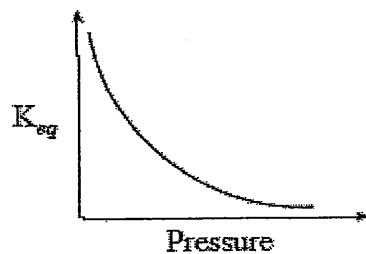


D.

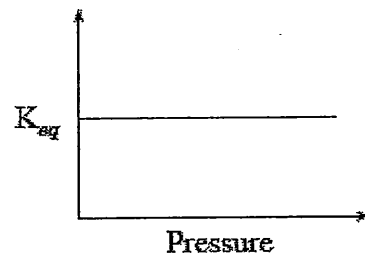


59. The relationship between K_{eq} and the pressure of a gaseous equilibrium at constant temperature can be best described by:

A.



B.



C.

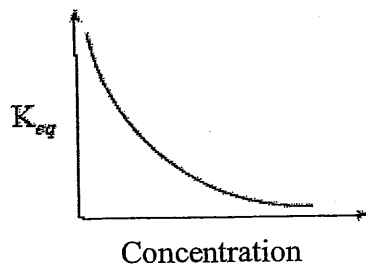


D.

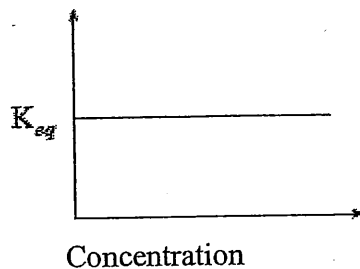


60. The relationship between K_{eq} and the concentrations of reactants in the same equilibrium system at constant temperature can best be described by

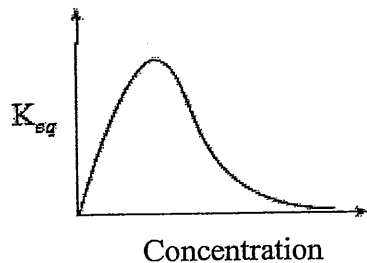
A.



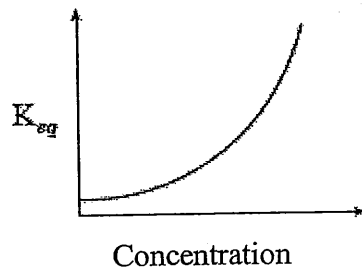
B.



C.



D.



61. What will cause the K_{eq} for an exothermic reaction to increase?

- A. increasing temperature
- B. decreasing temperature
- C. increasing [reactant]
- D. decreasing [product]

62. What will cause the value of K_{eq} for an endothermic reaction to increase?

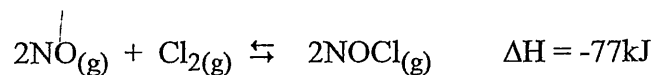
- A. decrease [products]
- B. decrease the temperature
- C. increase [products]
- D. increase the temperature

63. What will cause the value of K_{eq} for an exothermic reaction to decrease?

- A. decreasing the pressure
- B. decreasing the temperature
- C. increasing the pressure
- D. increasing the temperature

64. Consider the following equilibrium:

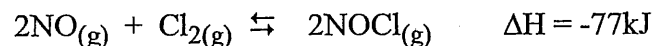
65. Consider the following equilibrium system:



In which direction will the equilibrium shift and what happens to the value of K_{eq} when the volume of the system is increased?

- | Shift | K_{eq} |
|----------|-----------------|
| A. right | stays constant |
| B. left | decreases |
| C. right | increases |
| D. left | stays constant |

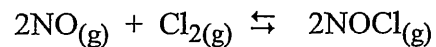
66. Consider the following equilibrium system:



In which direction will the equilibrium shift and what happens to the value of K_{eq} when the temperature of the system is decreased?

- | Shift | K_{eq} |
|----------|-----------------|
| A. left | stays constant |
| B. left | decreases |
| C. right | increases |
| D. right | stays constant |

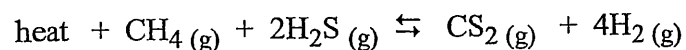
67. Consider the following equilibrium system:



In which direction will the equilibrium shift and what happens to the value of K_{eq} when the temperature of the system is increased?

- | Shift | K_{eq} |
|----------|-----------------|
| A. left | stays constant |
| B. left | decreases |
| C. right | increases |
| D. right | stays constant |

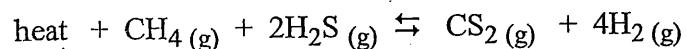
68. The following equilibrium is established in a 1.0 L container:



If some CH_4 is added to the system, what happens to the net concentration of CH_4 and the value of K_{eq} ?

- | [CH_4] | K_{eq} |
|-------------------|------------------|
| A. decreased | remains constant |
| B. decreased | increased |
| C. increased | remains constant |
| D. increased | increased |

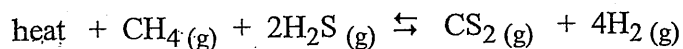
69. The following equilibrium is established in a 1.0 L container:



If some heat is removed from the system, what happens to the net concentration of CH_4 and the value of K_{eq} ?

- | [CH_4] | K_{eq} |
|-------------------|------------------|
| A. decreased | remains constant |
| B. increased | remains constant |
| C. decreased | increased |
| D. increased | decreased |

70. The following equilibrium is established in a 1.0 L container:



If the volume of the container is reduced to 0.50 L, what happens to the net concentration of CH_4 and the value of K_{eq} ?

- | [CH_4] | K_{eq} |
|-------------------|------------------|
| A. decreased | remains constant |
| B. increased | remains constant |
| C. decreased | increased |
| D. increased | decreased |

71. A container is initially filled with pure SO_2 . After a period of time, the following equilibrium is

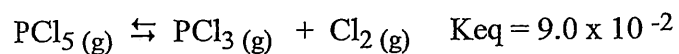
72. Which of the following reactions will proceed furthest toward completion?

- A. $2\text{H}_2\text{O}(\text{g}) \rightleftharpoons 2\text{H}_2(\text{g}) + \text{O}_2(\text{g})$ $K_{\text{eq}} = 7.3 \times 10^{-18}$
B. $\text{C}_2\text{H}_4(\text{g}) + \text{H}_2(\text{g}) \rightleftharpoons \text{C}_2\text{H}_6(\text{g})$ $K_{\text{eq}} = 9.0 \times 10^{19}$
C. $2\text{HBr}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{Br}_2(\text{g})$ $K_{\text{eq}} = 7.0 \times 10^{-20}$
D. $\text{Si}(\text{s}) + \text{O}_2(\text{g}) \rightleftharpoons \text{SiO}_2(\text{s})$ $K_{\text{eq}} = 2.0 \times 10^{142}$

73. In which of the following equilibria does the concentration of reactants equal the concentration of products?

- A. $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$ $K_{\text{eq}} = 1.00$
B. $\text{CO}_2(\text{g}) + \text{H}_2(\text{g}) \rightleftharpoons \text{CO}(\text{g}) + \text{H}_2\text{O}(\text{g})$ $K_{\text{eq}} = 0.279$
C. $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$ $K_{\text{eq}} = 0.71$
D. $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightleftharpoons \text{H}_2\text{O}(\text{l})$ $K_{\text{eq}} = 1.0 \times 10^{14}$

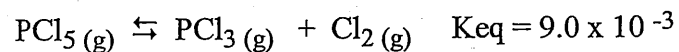
74. Consider the following equilibrium:



In a 1.0 L container an equilibrium mixture contains 6.0×10^{-3} mol PCl_5 and 1.0×10^{-2} mol PCl_3 . How many moles of Cl_2 are also present at equilibrium?

- A. 5.4×10^{-2}
B. 1.5×10^{-1}
C. 5.4×10^{-6}
D. 6.7×10^{-4}

75. Consider the following equilibrium:

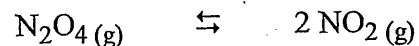


In a 1.0 L container an equilibrium mixture contains 2.5×10^{-3} mol PCl_5 , 1.0×10^{-2} mol PCl_3 and 1.0×10^{-2} mol of Cl_2 . How does the equilibrium shift and why?

- A. $K_{\text{eq}} < K_{\text{trial}}$ and equilibrium shifts left
B. $K_{\text{eq}} < K_{\text{trial}}$ and equilibrium shifts right
C. $K_{\text{eq}} > K_{\text{trial}}$ and equilibrium shifts left
D. $K_{\text{eq}} > K_{\text{trial}}$ and equilibrium shifts right

note
move to 98 or 99

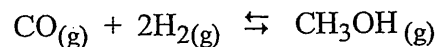
76. Consider the following:



An equilibrium mixture contains 4.0×10^{-2} mol of N_2O_4 and 1.5×10^{-2} mol of NO_2 in a 1.0 L flask. What is the K_{eq} ?

- A. 7.5×10^{-1}
- B. 5.6×10^{-3}
- C. 1.8×10^2
- D. 3.8×10^{-1}

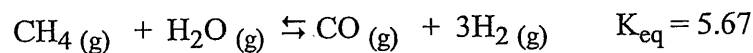
77. Consider the following equilibrium:



At equilibrium it was found that $[\text{CO}] = 0.105$ mol/L, $[\text{H}_2] = 0.250$ mol/L and $[\text{CH}_3\text{OH}] = 0.00261$ mol/L. Which of the following is the equilibrium constant value?

- A. 0.398
- B. 10.0
- C. 9.94×10^{-2}
- D. 2.51

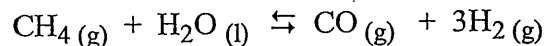
78. Consider the following equilibrium:



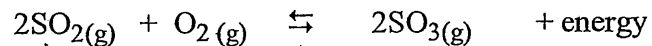
An equilibrium mixture of this system was found to contain the following concentrations: $[\text{CH}_4] = 0.59$ M, $[\text{H}_2\text{O}] = 0.63$ M, $[\text{CO}] = 0.25$ M. What was the equilibrium $[\text{H}_2]$?

- A. 0.64 M
- B. 8.4 M
- C. 0.26 M
- D. 2.0 M

79. Consider the following equilibrium:



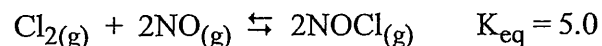
80. Consider the following equilibrium:



Initially, some SO_3 is placed into a 3.0 L container. At equilibrium there is 0.030 mol SO_2 present. What is the $[\text{O}_2]$ at equilibrium?

- A. 0.0050 mol/L
- B. 0.030 mol/L
- C. 0.015 mol/L
- D. 0.010 mol/L

81. Consider the following equilibrium:



At equilibrium $[\text{Cl}_2] = 1.0 \text{ M}$ and $[\text{NO}] = 2.0 \text{ M}$. What is the $[\text{NOCl}]$ at equilibrium?

- A. 4.5 M
- B. 10 M
- C. 0.80 M
- D. 0.89 M

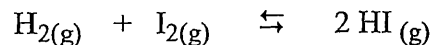
82. Consider the following equilibrium:



Initially, some NH_3 is placed into a 1.0 L container and allowed to reach equilibrium. At equilibrium there is 0.030 mol N_2 present. What is the $[\text{H}_2]$ at this equilibrium?

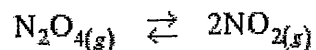
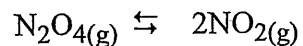
- A. 0.060 mol/L
- B. 0.090 mol/L
- C. 0.010 mol/L
- D. 0.030 mol/L

83. Consider the following:



Initially, some HI is placed into a 1.0 L container. At equilibrium there is 0.010 mol H_2 , 0.010

84. Consider the following equilibrium and the table of experimental data:

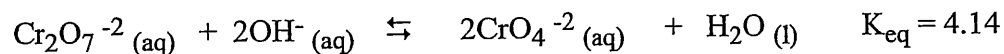


	Initial		Equilibrium	
	$[\text{N}_2\text{O}_4]$	$[\text{NO}_2]$	$[\text{N}_2\text{O}_4]$	$[\text{NO}_2]$
Trial 1	0.0400	0.0000	0.0337	0.0125
Trial 2	0.0200	0.0600	0.0429	0.0141

Which of the following represents the K_{eq} value?

- A. 7.42×10^{-1}
- B. 2.16×10^2
- C. 4.64×10^{-3}
- D. 3.71×10^{-1}

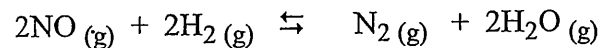
85. Consider the following equilibrium:



The concentration of ions at equilibrium was measured at a specific temperature and found to be $[\text{Cr}_2\text{O}_7^{2-}] = 0.100 \text{ M}$ and $[\text{OH}^-] = 0.020 \text{ M}$. What is the equilibrium $[\text{CrO}_4^{2-}]$?

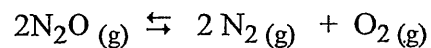
- A. $1.3 \times 10^{-2} \text{ M}$
- B. $2.0 \times 10^{-1} \text{ M}$
- C. $3.1 \times 10^{-3} \text{ M}$
- D. $1.7 \times 10^{-4} \text{ M}$

86. Consider the following equilibrium:



Initially, 0.100 mol NO, 0.0500 mol H_2 and 0.100 mol H_2O are placed in a 1.0 L container. At

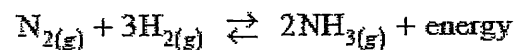
87. Consider the following equilibrium:



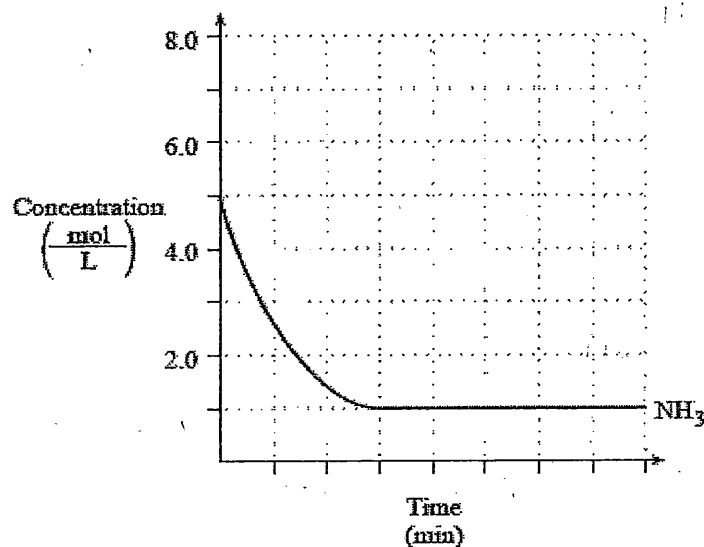
Initially, 0.800 mol N_2O is placed in a 1.0-L container. At equilibrium, the $[\text{N}_2]$ is found to be 0.780 M. What is the value of K_{eq} ?

- A. 1.7×10^{-3}
- B. 1.2×10^3
- C. 5.9×10^2
- D. 1.5×10^1

88. Consider the following equilibrium:



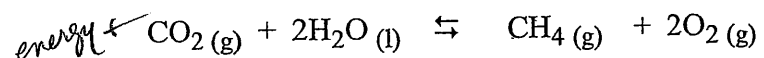
A 1.00 L container is filled with 5.0 mol NH_3 and the system proceeds to equilibrium as indicated by the graph.



a. Draw and label the graph for N_2 and H_2 .

b. Calculate the K_{eq} for $\text{N}_{2(\text{g})} + 3\text{H}_{2(\text{g})} \rightleftharpoons 2\text{NH}_{3(\text{g})}$

89. Consider the following equilibrium:



Initially, 0.450 moles of CO_2 , 0.480 moles of H_2O , 0.250 moles of CH_4 and 0.500 moles of O_2 are placed in a 5.00 L container and allowed to reach equilibrium.

a. When equilibrium is reached, the $[\text{O}_2]$ is 0.0700 M. Calculate the K_{eq} of the equilibrium.

b. Are reactants or products favored? _____ Explain your answer.

c. How would the following stresses affect the equilibrium? Complete the table below using the arrows indicated.

shift left (from shock) \leftarrow increased rate of forward reaction after equilibrium reestablished \uparrow
 shift right (from shock) \rightarrow decreased rate of forward reaction after equilibrium reestablished \downarrow
 no shift - no change in rate -

Stress (shock) introduced	Equilibrium shift	$[\text{CO}_2]$ (after shifting)	Forward reaction rate (after equilibrium is back)
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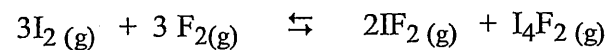
Decrease pressure

add $\text{CH}_4(\text{g})$

increase temperature

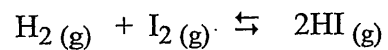
add catalyst

90. Consider the following equilibrium:



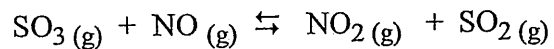
Initially 2.00×10^{-1} mol of I_2 and 3.00×10^{-1} mol of F_2 and 1.00×10^{-1} mol of I_4F_2 are put into a 10.00 L flask. At equilibrium $[\text{IF}_2]$ is 2.00×10^{-3} M. Calculate the value of K_{eq} .

91. Consider the following:



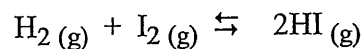
Initially, 0.200 mol of H_2 and 0.200 mol I_2 are added to an empty 2.00 L container. At equilibrium $[\text{I}_2]$ is 0.020 mol/L. Calculate the value of K_{eq} .

92. Consider the following equilibrium:



In an experiment, 0.100 moles of SO_3 and 0.100 moles of NO are placed in a 1.00 L container. When equilibrium is achieved, $[\text{NO}_2] = 0.0414 \text{ mol/L}$. Calculate the K_{eq} value.

93. Consider the following equilibrium:



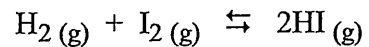
$K_{\text{eq}} = 49.5$ at 440°C

get rid of?

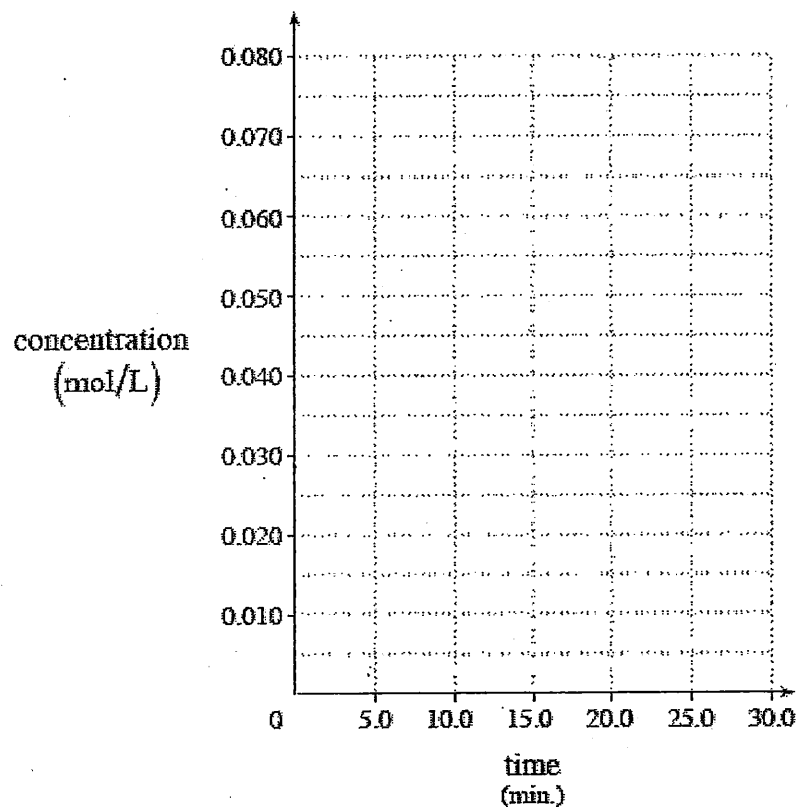
If 5.0 M HI is initially placed into a container at 440°C , what will be the equilibrium $[\text{HI}]$?

- A. 3.9 M
- B. 4.8 M
- C. 0.33 M
- D. 4.4 M

94. Consider the following equilibrium:



A 2.0 L container is initially filled with 0.070 mol of H_2 and 0.060 mol of I_2 .

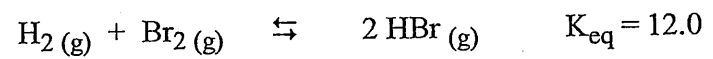


Equilibrium is reached after 15.0 minutes, at which time there are 0.060 mol of HI present.

a. Sketch the graph for $[\text{H}_2]$, $[\text{I}_2]$ and $[\text{HI}]$ for the first 15 minutes.

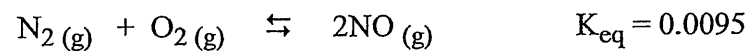
b. Calculate the K_{eq} for this equilibrium at 15 minutes.

95. Consider the following:



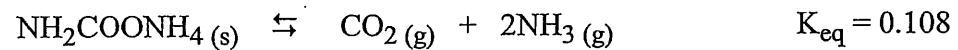
Initially, 0.080 mol H_2 and 0.080 mol of Br_2 are placed into a 4.00 L container. What is the $[\text{HBr}]$ at equilibrium?

96. Consider the following equilibrium:



Initially, 0.15 mol N_2 and 0.15 mol O_2 were placed in a 1.0 L container. Calculate the concentration of all species at equilibrium.

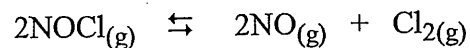
97. Consider the following equilibrium:



Initially, 2.00 moles of $\text{NH}_2\text{COONH}_4$ are placed in a 500.0 mL container. Calculate $[\text{NH}_3]$ at equilibrium.

do 75 as example

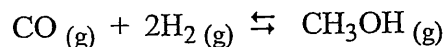
98. Consider the following equilibrium:



A flask is filled with NOCl, NO and Cl₂. Initially, there was a total of 5.0 moles of gases present. When equilibrium is reached, there is a total of 6.0 moles of gases present. Which of the following explains this observation?

- A. The reaction shifted left because $K_{\text{trial}} < K_{\text{eq}}$.
- B. The reaction shifted right because $K_{\text{trial}} < K_{\text{eq}}$.
- C. The reaction shifted left because $K_{\text{trial}} > K_{\text{eq}}$.
- D. The reaction shifted right because $K_{\text{trial}} > K_{\text{eq}}$.

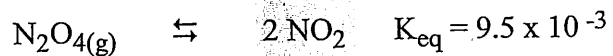
99. Consider the following equilibrium:



Some CO, H₂ and CH₃OH were placed in a 1.0 L container. When equilibrium was established, the [CO] had increased. Which of the following is true?

- A. Trial $K_{\text{eq}} > K_{\text{eq}}$ so reaction shifted right to reach equilibrium.
- B. Trial $K_{\text{eq}} < K_{\text{eq}}$ so reaction shifted right to reach equilibrium.
- C. Trial $K_{\text{eq}} < K_{\text{eq}}$ so reaction shifted left to reach equilibrium.
- D. Trial $K_{\text{eq}} > K_{\text{eq}}$ so reaction shifted left to reach equilibrium.

100. Consider the following equilibrium:



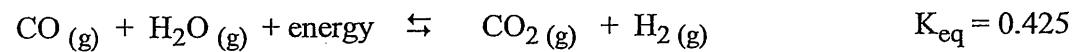
put in state.

Initially, 0.060 mol N₂O₄ and 0.020 mol NO₂ are placed in a 2.00 L container.

Determine the direction in which the reaction will proceed in order to reach equilibrium.

- A. It will shift to the left because $K_{\text{trial}} < K_{\text{eq}}$.
- B. It will shift to the right because $K_{\text{trial}} < K_{\text{eq}}$.
- C. It will shift to the right because $K_{\text{trial}} > K_{\text{eq}}$.
- D. It will shift to the left because $K_{\text{trial}} > K_{\text{eq}}$.

101. Consider the following equilibrium:



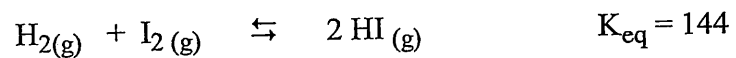
Initially there are 0.180 mol of CO, 0.180 mol of H₂O, 0.160 mol of CO₂ and 0.160 mol of H₂ in a 2.00 L container.

a. Is the container of gases at equilibrium? If not, which way will the equilibrium shift to reach equilibrium?

b. Calculate the [CO] and [CO₂] when equilibrium is reached.

c. What could be done to the equilibrium to increase the K_{eq} ?

102. Consider the following equilibrium:

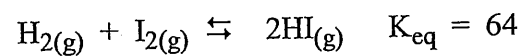


Initially 0.480 mol of HI, 0.160 mol of H_2 and 0.160 mol of I_2 are placed in a 2.00 L container and allowed to reach equilibrium.

a. Which way will the equilibrium shift in order to reach equilibrium?

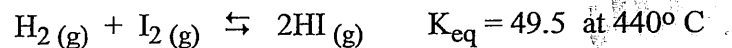
b. What will be the $[\text{HI}]$ at equilibrium?

103. Given the following reaction:



Equal moles of H_2 , I_2 and HI are placed in a 1.0 L container. Use calculations to determine the direction the reaction will proceed in order to reach equilibrium.

104. Consider the following equilibrium:



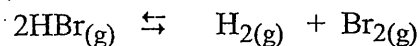
Get rid of?

If 0.120 M H_2 , 0.120 M I_2 and 0.844 M HI are initially placed into a container at 440°C , which of the following is true as equilibrium is approached?

- A. $[\text{H}_2]$ remains the same.
- B. $[\text{H}_2]$ decreases significantly
- C. $[\text{I}_2]$ decreases significantly
- D. $[\text{HI}]$ decreases significantly

F9 Review

105. Consider the following:



Initially, HBr is added to an empty flask. How do the rate of the reverse reaction and the $[\text{HBr}]$ change as the system proceeds to equilibrium?

- | | Reverse Rate | $[\text{HBr}]$ |
|----|--------------|----------------|
| A. | increases | increases |
| B. | increases | decreases |
| C. | decreases | decreases |
| D. | decreases | increases |

106. In which of the following equations does entropy most favour reactants?

- A. $\text{NH}_4\text{Cl}(\text{s}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{Cl}^-(\text{aq})$
- B. $\text{SnO}_2(\text{s}) + 2\text{H}_2(\text{g}) \rightleftharpoons \text{Sn}(\text{s}) + 2\text{H}_2\text{O}(\text{g})$
- C. $\frac{1}{2}\text{N}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons \text{NO}_2(\text{g})$
- D. $4\text{PH}_3(\text{g}) \rightleftharpoons \text{P}_4(\text{g}) + 6\text{H}_2(\text{g})$

107. When the temperature of an endothermic equilibrium is increased, which of the following will happen?

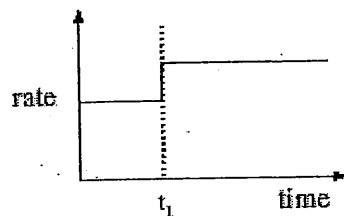
- A. Equilibrium shifts right and [reactant] increases
- B. Equilibrium shifts left and [product] increases

108. Consider the following equilibrium:

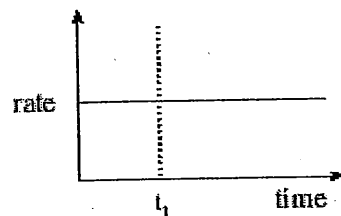


Which of the following shows the reverse rate of reaction when the volume is decreased at time = t_1 ?

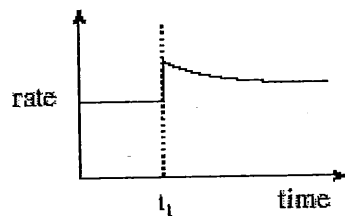
A.



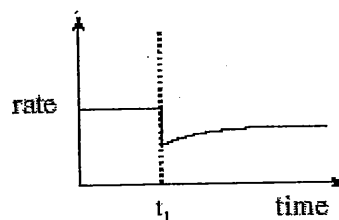
B.



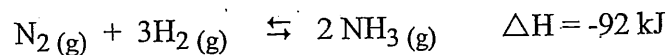
C.



D.



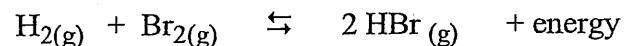
109. Consider the following reaction for the Haber Process for ammonia production:



The system is normally maintained at a temperature of approximately 500°C . Why is the temperature of 1000°C not used?

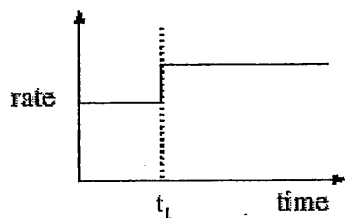
- The equilibrium would shift to the right, reducing % yield.
- The equilibrium would shift to the left, reducing % yield.
- The forward reaction would change from exothermic to endothermic and equilibrium would be lost.
- Too many collisions would decrease the number of successful collisions thus reducing the % yield.

110. Consider the following equilibrium:

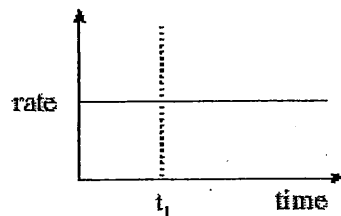


Which of the following shows the forward reaction rate when the temperature is decreased at time = t_1 ?

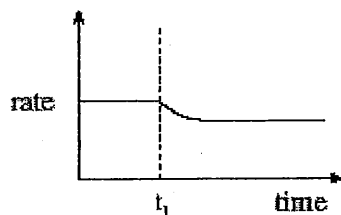
A.



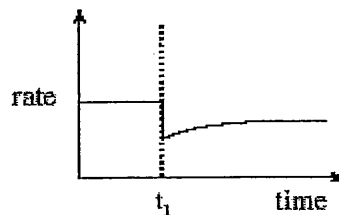
B.



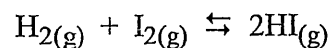
C.



D.



111. Consider the following equilibrium:



$$\Delta H = -71.9 \text{ kJ}$$

Change to -9.4 kJ

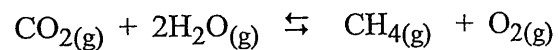
Which of the following would allow you to conclude that the system has reached equilibrium?

- A. $[\text{H}_2(\text{g})] = [\text{I}_2(\text{g})]$
- B. The temperature remains constant
- C. The gas pressure remains constant
- D. $[\text{H}_2(\text{g})] = 2[\text{HI}(\text{g})]$

112. Which reaction has the following equilibrium expression?

$$K = \frac{[\text{NO}_2]^4 [\text{H}_2\text{O}]^6}{[\text{N}_2\text{O}_4] [\text{H}_2\text{O}_2]^6}$$

113. Consider the following equilibrium:

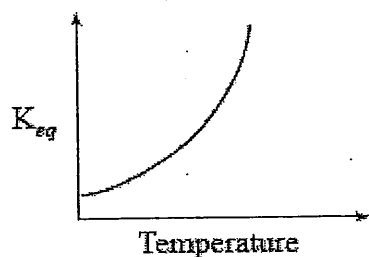


Which of the options below indicates that the reactants are favoured?

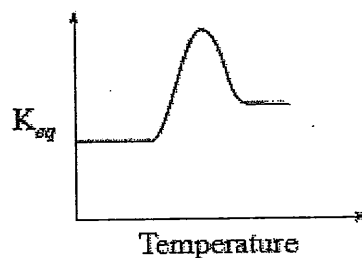
- A. K_{eq} is slightly greater than 1
- B. K_{eq} is slightly less than 1
- C. K_{eq} is zero
- D. K_{eq} is very large

114. Which of the following best describes the relationship between K_{eq} and temperature for an exothermic forward reaction?

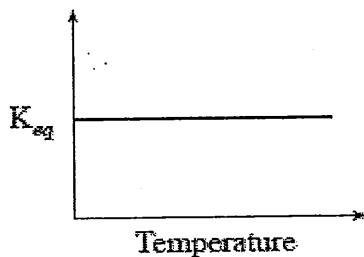
A.



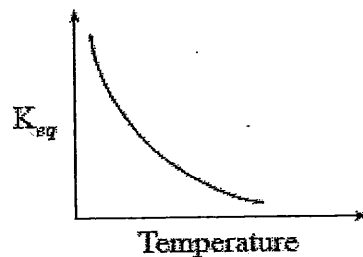
B.



C.



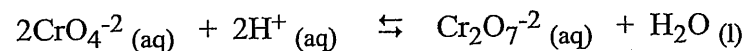
D.



115. What will cause the value of K_{eq} for an exothermic reaction to increase?

- A. decrease the temperature
- B. increase the temperature
- C. decrease the volume
- D. increase the volume

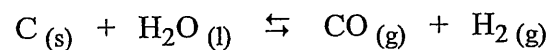
116. Consider the following equilibrium:



A solution of $\text{Ba}(\text{NO}_3)_2$ is added, and a precipitate of BaCrO_4 forms. What could you add to the solution to dissolve the precipitate, and predict the equilibrium shift and change to K_{eq} .

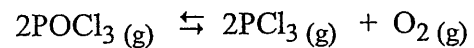
Add	Equilibrium shift	K_{eq}
A. H_2O	left	remains constant
B. $\text{Cr}_2\text{O}_7^{-2}$	left	decreases
C. H^+	right	remains constant
D. CrO_4^{-2}	right	increases

117. Consider the following equilibrium:



At equilibrium, 4.0×10^{-2} mol H_2 , 4.0×10^{-2} mol CO , 1.0×10^{-2} mol H_2O and 1.0×10^{-2} mol C were present in a 1.0 L container. What is the value of K_{eq} ?

118. Consider the following equilibrium:



3.00 moles of POCl_3 were put into a 2.00 L container and allowed to reach equilibrium. At equilibrium $[\text{O}_2] = 0.0250 \text{ M}$.

a. Use the concepts of entropy and enthalpy to predict whether or not the forward reaction will be endothermic or exothermic.

b. List three ways that you could shift the equilibrium to the product side.

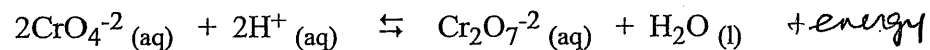
(1)

(2)

(3)

c. Calculate the K_{eq} for the above container when equilibrium is reached.

119. Consider the following equilibrium:



Initially, 0.450 moles of $\text{Cr}_2\text{O}_7^{-2}$, 0.480 moles of H_2O , 0.250 moles of CrO_4^{-2} and 0.500 moles of H^+ are placed in a 5.00 L container and allowed to reach equilibrium.

a. When equilibrium is reached, the $[\text{Cr}_2\text{O}_7^{-2}]$ is 0.100 M. Calculate the K_{eq} of the equilibrium.

b. Are reactants or products favored? _____ Explain your answer.

c. How would the following stresses affect the equilibrium? Complete the table below using the arrows indicated.

shift left (from shock) \leftarrow increased rate of forward reaction after equilibrium reestablished \uparrow
 shift right (from shock) \rightarrow decreased rate of forward reaction after equilibrium reestablished \downarrow
 no shift - no change in rate -

Stress (shock) introduced	Equilibrium shift	$[\text{Cr}_2\text{O}_7^{-2}]$ (after shifting)	Forward reaction rate (after equilibrium is back)
---------------------------	-------------------	---	---

Decrease pressure

add $\text{CrO}_4^{-2}(\text{aq})$

increase temperature

120. Consider the following equilibrium:



Initially, 0.240 moles of CO_2 , 0.240 moles of H_2 , 0.150 moles of H_2O and 0.150 moles of CO are placed in a 3.00 L container.

- a. Is the container at equilibrium? _____
If not, which way will the equilibrium shift in order to reach equilibrium.
Support your answer with calculations.

- b. Calculate the $[\text{CO}]$ and $[\text{CO}_2]$ at equilibrium.

C

C

