1. For the reaction:

 $\begin{array}{c} BrO_{3}^{-} + 5Br^{-} + 6H + \rightarrow 3Br_{2} + 3H_{2}O\\ If the value of -\Delta[Br^{-}]/\Delta t = 7.5 \times 10^{-2} \text{ mol } L^{-1} \text{ s}^{-1}, \text{ What will be the value of } \Delta\\ [Br_{2}]/\Delta t \text{ at the same instant (in mol } L^{-1} \text{ s}^{-1})?\\ \underline{A) \quad 1.25 \times 10^{-2} \quad B) \quad 1.5 \times 10^{-2} \quad C) \quad 4.5 \times 10^{-2} \quad D) \quad 1.25 \times 10^{-1}\\ \hline\\ SOLUTION\\ -\frac{\Delta[Br^{-}]}{5 \times \Delta t} = +\frac{\Delta[Br_{2}]}{3 \times \Delta t}, -\frac{\Delta[Br^{-}]}{\Delta t} = +\frac{\Delta[Br_{2}]}{\Delta t} = -\frac{3 \times \Delta[Br^{-}]}{5 \times \Delta t} = \frac{3 \times 7.5 \times 10^{-2}}{5} = 0.045 \text{ mol } L^{-1} \text{ s}^{-1}\\ \end{array}$

2. Nitric oxide reacts with chlorine to form nitrosyl chloride:

$NO + 1/2Cl_2 \rightarrow NOCl$						
From the follo	From the following data, the reaction rate law (rate equation) is:					
	Exper	[NO]	[Cl ₂]	Initial rate		
	iment	(M)	(M)	$(M \min^{-1})$		
	1	0.22	0.064	0.96		
	2	0.66	0.064	8.64		
	3	0.22	0.032	0.48		
A) Rate = k $[NO]^2 [Cl_2]^2$ B) Rate = k $[NO]^2 [Cl_2]^{1/2}$						
C) Rate = k [NO] $[Cl_2]^{1/2}$ D) Rate = k $[NO]^2 [Cl_2]$						
SOLUTION						
rate = $\mathbf{k}[\mathbf{NO}]^{\mathbf{x}}[\mathbf{Cl}_2]^{\mathbf{y}}$						
$\frac{\text{rate}_2}{1} = \frac{k [\text{NO}]_2^x [\text{Cl}_2]_2^x}{2} = \frac{8.64}{1000} = (\frac{0.66}{1000})^x = 9 - 3^x = 7$						
rate ₁ $k [NO]_1^x [Cl_2]_1^x$, 0.96 $(0.22)^{7,7} = 0^{7,8} = 2$						
$\frac{\text{rate}_3}{1} = \frac{k \left[\text{NO}_2 \right]_3^{y} \left[\text{Cl}_2 \right]_3^{y}}{1} = \left(\frac{0.32}{10} \right)^{y}, \frac{1}{2} = \left(\frac{1}{2} \right)^{y}, \mathbf{v} = 1$						
rate ₁ k $[NO_2]_1^{y}[Cl_2]_1^{y}$ 0.96 $(0.64')^2 (2')^{y} = 2$						
rate = $k[NO]^2[Cl_2]$						

3. At 25°C, the rate constant for the first order decomposition of a pesticide solution is 6.4×10⁻³ min⁻¹. If the initial concentration of pesticide is 0.0314 mol L⁻¹. What its concentration (in mol L⁻¹) after 62.0 min at 25°C?

A) 0.011
B) 0.0131
C) 0.0191
D) 0.0211

SOLUT	ION
$\ln \frac{[\text{pesticide}]_0}{[\text{pesticide}]_t} = \text{kt}, \ln \frac{0.0314}{[\text{pesticide}]_t} = 6.4 \times 10^{-3} \times 10^{-3}$	62, $[pesticide]_t = 0.0211 \text{ mol } L^{-1}$

4. A first order reaction has a rate constant of 2.8×10⁻² s⁻¹. How many seconds will it take for the [reactant] to decrease from 0.88 mol L⁻¹ to 0.14 mol L⁻¹?
A) 59.5 B) 65.7 C) 74.8 D) 88.6

$$\ln \frac{[\text{reactant}]_0}{[\text{reactant}]_t} = \text{kt}, \ln \frac{0.88}{0.14} = 2.8 \times 10^{-2} \times \text{t}, \text{ t} = 65.65 \text{ min}$$

5. Increasing of which of the following would alter the value of the rate constant (k) for the reaction?

$2\mathbf{A} + \mathbf{B} \rightarrow \mathbf{products}$							
A)	[A] only	B) [B] only	C) [A] and [B]	D) temperature			

SOLUTION According to Arrhenius equation, $lnk = lnA - \frac{E_a}{RT}$, it appears that k value depends on the values of A, E_a , R, and T. The values of A and E_a are constant for the same reaction, and the value of R is always constant. Therefore, k cannot be increased unless T is increased.

6. The isomerization of cyclopropane follows first order kinetics. The rate constant at 700 K is 6.2×10⁻⁴ min⁻¹, and the half life at 760 K is 29.0 min. The activation energy for this reaction, in kJ/mol, is:

A) 269.2 B) 250.6 C) 240.8 D) 283.4
SOLUTION

$$k(760 \text{ K}) = \frac{\ln 2}{t_{0.5}} = \frac{0.693}{29} = 2.39 \times 10^{-2}$$

 $\ln \frac{k_1}{k_2} = \frac{E_a}{R} (\frac{T_1 - T_2}{T_1 \times T_2}), \ln \frac{6.2 \times 10^{-4}}{2.39 \times 10^{-2}} = \frac{E_a}{8.314 \times 10^{-3}} (\frac{700 - 760}{700 \times 760}), E_a = 269.2 \text{ kJ}$

7. The unit for a third order reaction rate constant is:

A)
$$s^{-1}$$
 B) $mol^{-2} L^2 s^{-1}$ C) $mol^2 L^{-2} s^{-1}$ D) $mol^3 L^{-3} s^{-1}$
SOLUTION
k UNITS = $mol^{1-n} L^{n-1} s^{-1} = mol^{1-3} L^{3-1} s^{-1} = mol^{-2} L^2 s^{-1}$

8. The correct equilibrium constant expression for the following reaction is:

$$Fe_{2}O_{3}(s) + 3H_{2}(g) \approx 2Fe(s) + 3H_{2}O(g)$$
A) $K_{c} = [H_{2}O]^{3}/[H_{2}]^{3}$
B) $K_{c} = [Fe]^{2}[H_{2}O]^{3}/[Fe_{2}O_{3}][H_{2}]^{3}$
C) $K_{c} = [Fe_{2}O_{3}][H_{2}]^{3}/[Fe]^{2}[H_{2}O]^{3}$
D) $K_{c} = [H_{2}O]/[H_{2}]$
SOLUTION
 $K_{c} = [Fe]^{2}[H_{2}O]^{3}/[Fe_{2}O_{3}][H_{2}]^{3}$

9. From the following equilibria, K₁ and K₂ are related by:

$$\begin{split} SO_2(g) + 1/2O_2(g) &\rightleftharpoons SO_3(g) & K_1 \\ 2SO_3(g) &\rightleftharpoons 2SO_2(g) + O_2(g) & K_2 \\ A) & K_2 &= (K_1)^2 & B) & (K_2)^2 &= K_1 & C) & K_2 &= (K_1)^{-2} & D) & K_2 &= (K_1)^{-1} \\ \hline SOLUTION \\ From the equilibrium constants of both reactions: \\ K_1 &= [SO_3]/[SO_2][O_2]^{1/2} \\ K_2 &= [SO_2]^2[O_2]/[SO_3]^2 \\ It appears that & K_2 &= (K_1)^{-2} \end{split}$$

10. Knowing that

 $\begin{array}{ll} NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g) & K_c(295\ K) = 1.2 \times 10^{-4} \\ The \ equilibrium \ partial \ pressure \ of \ NH_3(g) \ is: \\ A) \ 0.117 & B) \ 0.265 & C) \ 0.344 & D) \ 0.424 \end{array}$

	SOLUTION			
	Because this is a he	eterog	eneous equilibrium:	
$\mathbf{K}_{c} = [\mathbf{NH}_{3}][\mathbf{H}_{2}\mathbf{S}]$ and $\mathbf{K}_{p} = \mathbf{P}_{\mathbf{NH}_{3}} \times \mathbf{P}_{\mathbf{H}_{2}\mathbf{S}}$				
	$\mathbf{K}_{\mathbf{p}} = \mathbf{K}_{\mathbf{c}} (\mathbf{R} \times \mathbf{T})^{\Delta \mathbf{n}_{\mathbf{g}}}$		$K_c = [NH_3][H_2S] = 1.2 \times 10^{-4}$]
	$K_p = 1.2 \times 10^{-4} (0.0821 \times 295)^2$		$[NH_3] = [H_2S] = \sqrt{1.2 \times 10^{-4}}$	
	$K_{p} = 0.0703$		$[NH_3] = 0.01095 M$	
	$K_{p} = P_{NH_{3}} \times P_{H_{2}S} = 0.0703$	OR	$\mathbf{P}_{\mathbf{NH}_3} = \frac{\mathbf{n}}{\mathbf{v}} \times \mathbf{R} \times \mathbf{T} = [\mathbf{NH}_3] \times \mathbf{R} \times \mathbf{T}$	
	$P_{NH_3} = P_{H_2S} = \sqrt{0.0703}$		$P_{\rm NH_3} = 0.0109 \times 0.0821 \times 295$	
	$P_{\rm NH_3} = 0.265 { m atm}$		$P_{\rm NH_3} = 0.265 { m atm}$	

11. For following reaction at equilibrium:

$2SO_2(g) + O_2(g) \Rightarrow 2SO_3(g)$	$\Delta \mathbf{H}_{\mathbf{rxn}} = -198 \ \mathbf{kJ}$				
Which of the following statements could be true? K _p increases with:					
1).decreasing temperature.	2) increasing temperature.				
3) decreasing total pressure.	4) increasing total pressure.				
A) 1 only B) 1 and 4	C) 2 only D) 2 and 3				
SOLUTION					
Equilibrium constant for any reaction does not change except if its					
temperature changes. And for exothermic reactions equilibrium constants					
increases as temperature decreases.					

4.21 moles of S₂Cl₄ gas are introduced in 2.0 L vessel, and at equilibrium
1.25 moles of S₂Cl₄ are found in the reaction vessel, and K_c for the reaction is:



13. If the following equilibrium mixture concentrations are $[SO_3] = 10.00$ M, $[SO_2] = 0.01$ M and $[O_2] = 0.10$ M at 700 K:

$$2SO_2(g) + O_2(g) \Rightarrow 2SO_3(g)$$
 $K_c(700 \text{ K}) = 4.3 \times 10^6$,

A) the reaction mixture is at equilibrium.

B) the reaction must proceed to the right to reach equilibrium.

C) the reaction must proceed to the left to reach equilibrium.

D) there is not enough information to answer.

SOLUTION

$$Q = \frac{[SO_3]^2}{[SO_2]^2[O_2]} = \frac{(10)^2}{(0.01)^2 \times (0.1)} = 1\ 00 \times 10^7$$

 $1.00 \times 10^{-7} > 4.3 \times 10^{6}$ Because Q > K_c, the reaction must proceed to the left to reach equilibrium.

14. What is the pH of 1.0 L buffer solution that is 0.12 M lactic acid, $HC_3H_5O_3$, and 0.10 M sodium lactate, $NaC_3H_5O_3$, after the addition of 0.01 mole of gaseous HCl? assume that this will not change the volume of the solution, and $K_a(HC_3H_5O_3) = 1.4 \times 10^{-4}$.

A) 3.27 B) 3.45 C) 3.69 D) 3.95
SOLUTION

$$[S_2Cl_4]_{initial} = \frac{n_{S_2Cl_4}}{v} = \frac{4.21}{2} = 2.105 \text{ M}, [S_2Cl_4]_{equilibrium} = \frac{n_{SCl_2}}{v} = \frac{1.25}{2} = 0.625 \text{ M}$$

 $HC_3H_5O_3 + H_2O \Rightarrow C_3H_5O_3 + H_3O^+$
Before: 0.2 M 0.10 M
After: 0.2 + 0.01 = 0.21 M 0.10 - 0.01 = 0.09 M
 $pH = pK_a + \log \frac{[C_3H_5O_3]}{[HC_3H_5O_3]} = -\log 1.4 \times 10^{-4} + \log \frac{0.09}{0.21} = 3.48589$

- 15. The conjugated acid of NH_2^- is: A) HNO₃ B) HNO₂ C) NH_4^+ D) NH_3 SOLUTION Because the conjugate acid is more than its conjugate base by one H^+ , the conjugated acid of NH_2^- is NH_3 .
- 16. The pOH of 2.5×10^{-3} M Ba(OH)₂ solution is:

A) 5.0 B) 2.5 C) 2.3 D) 2.1
SOLUTION

$$[OH^-] = nC_b = 2 \times 2.5 \times 10^{-3} = 5 \times 10^{-3} \text{ M}, \text{ pOH} = -\log [OH^-] = -\log 5 \times 10^{-3} = 2.3$$

17. The pH of 100 ml of 0.002 M HCl solution is:

A) 0.27	B) 2.0	C) 0.2	D) 2.7			
SOLUTION						
$[H^+] = nC_a = 1 \times 0.002 = 0.002 \text{ M}, pH = -log [H^+] = -log 0.002 = 2.7$						

18. The pH of **1.6** M KOH solution is:

A)	13.8	B) 14.2	C) 12.4	D) 1.6		
SOLUTION						
$[OH^{-}] = nC_b = 1 \times !.6 = 1.6 \text{ M}, \text{ pOH} = -\log [OH^{-}] = -\log 1.6 = -0.204$						
pH 14 - pOH = 14 - (-0.204) = 14.204						

19. The pH of 0.05 M acetic acid (K_a = 1.8×10⁻⁵) solution is: A) 3 B) 4 C) 5 D) 6 SOLUTION $[H^+] = \sqrt{C_a K_a} = \sqrt{0.05 \times 1.8 \times 10^{-5}} = 9.487 \times 10^{-4} \text{ M, pH} = -\log [H^+]$ $pH = -\log 9.487 \times 10^{-4} = 3.02$

 20.
 The pH of 0.1 M ammonia (K_b = 1.8×10⁻⁵) solution is:

 A)
 2.87
 B) 11.13
 C) 8.94
 D) 12.56

SOLUTION	
$[OH^{-}] = \sqrt{C_b K_b} = \sqrt{0.1 \times 1.8 \times 10^{-5}} = 1.34 \times 10^{-3} \text{ M}, \text{ pOH} = -\log [OH^{-}]$ pOH = -log 1.34 × 10 ⁻³ × 10 ⁻⁴ = 2.87, pH = 11.13	