

General Chemistry I, 1st midterm exam., 2018-11-05

(Gas constant $R = 0.08206 \text{ L atm K}^{-1}\text{mol}^{-1}$ or $8.31451 \text{ J K}^{-1}\text{mol}^{-1}$, $1 \text{ Joule} = 1 \text{ kgm}^2/\text{s}^2$)

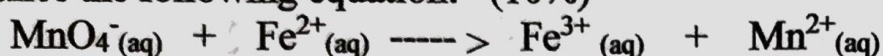
1. Name the following compounds in English (英文名稱) (18%)

(a) AgCl (b) NO (c) HClO (d) CO₂ (e) H₂SO₄ (f) Pb (g) Au (h) Hg (i) Al

2. What are the electronegativity values for the following atoms: (a) F (b) O (c) C (d) H (e) N (f) Na. (12%).

3. Write the English symbols of the first row transition metals from d¹ to d¹⁰ sequentially. (10%)

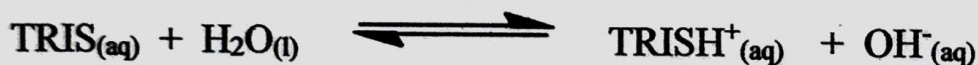
4. Balance the following equation: (10%)



5. There are two gases (CO₂, and H₂) in a container at 25°C in the molar ratio of 1:1. Calculate the (a) kinetic energy, and (b) average velocity of CO₂. Also calculate the (c) expected ratio (CO₂/H₂) of effusion rates through a tiny hole. (d) In an experiment, the measured ratio (CO₂/H₂) of effusion rates is smaller than the value calculated from the Graham's law. Explain why. (molecular weight, CO₂= 44, and H₂= 2 g/mol). (20%).

6. (a) What is the Le Chatelier's principle? (4%) (b) Derive the Henderson-Hasselbalch equation from the acid equilibrium constant (5%)

7. Tris(hydroxymethyl)aminomethane, commonly called TRIS or Trizzna, is often used as a buffer in biochemical studies. Its buffering range is from pH 7 to 9, and K_b is 1.19×10^{-6} for the reaction



a. What is the optimal (最佳的) pH for TRIS buffers?

b. Calculate the ratio (TRIS)/(TRISH⁺) at pH= 7.0

c. A buffer is prepared by diluting 50.0 g of TRIS base and 63.0 g of TRIS hydrochloride (written as TRIS·HCl) to a total volume of 2.0 L.

d. What is the pH of this buffer? What is the pH after 0.5 mL 12.0 M HCl is added to 200.0 mL portion of the buffer? (12%)

(Molecular weight, Mw, of TRIS is 121.1 g/mol; Mw of TRIS-HCl= 157.6 g/mol)

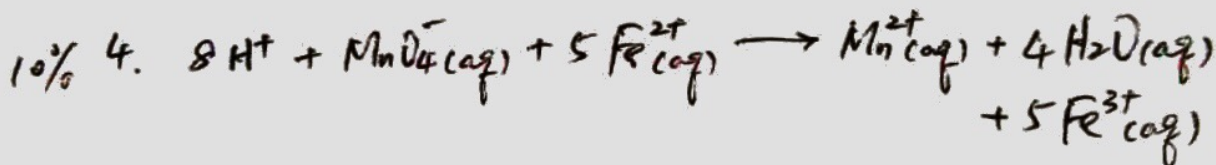
8. Solutions of sodium thiosulfate (Na₂S₂O₃) are used to dissolve un-exposed AgBr in the developing process for black-and-white film. What mass of AgBr can dissolve in 1.00 L of 0.5 M Na₂S₂O₃? Assume the overall formation constant for Ag(S₂O₃)₂³⁻ is 2.9×10^{13} and K_{sp} for AgBr is 5.0×10^{-13} . (9%) (Mw of AgBr is 187.8 g/mol).

✓ Answer To 1st midterm Exam. G.Chem. 2013-11-11

- 18% 1. (a) AgCl: silver chloride (b) NO: nitrogen monoxide (or nitric oxide)
(c) HClO: hypochlorite acid, (d) CO₂: carbon dioxide
(e) H₂SO₄: sulfuric acid (f) Pb: lead
(g) Au: gold (h) Hg: mercury (i) Al: aluminum

- 12% 2. (a) F: 4.0 (b) O: 3.5 (c) C: 2.5 (d) H: 2.1
(e) N: 3.0 (f) Na: 0.9
(answer ± 0.1 is considered correct)

- 10% 3. d¹ ~ d⁵ transition metal elements: Sc Ti V Cr Mn
d⁶ ~ d¹⁰ " " " " : Fe Co Ni Cu Zn



- 20% 5. (a) Kinetic Energy $KE = \frac{3}{2} RT$ independent of gases
 $= \frac{3}{2} (8.3145 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1}) \times 298.5 \text{ K}$
 $= 3722.8 \text{ J/mol}$
or 3.72 kJ/mol for both CO₂ & H₂.

$$\begin{aligned} \text{(b) } U_{\text{arg}} &= \sqrt{\frac{8RT}{\pi M}} = \sqrt{\frac{8 \times 8.3145 \text{ J} \cdot \text{K}^{-1} \cdot \text{mol}^{-1} \times 298.5 \text{ K}}{3.14159 \times 44 \text{ g/mol}}} \\ &= \sqrt{143.6 \text{ J/g}} \\ &= \sqrt{143.6 (\text{kg} \cdot \text{m}^2/\text{s}^2) \cdot \text{g}^{-1}} \\ &= \sqrt{14.36 \times 10^4 \text{ m}^2/\text{s}^2} \\ &= 379 \text{ m/s for CO}_2 \end{aligned}$$

$$5(c) \frac{U_{avg, CO_2}}{U_{avg, H_2}} = \sqrt{\frac{M_{H_2}}{M_{CO_2}}} = \sqrt{\frac{2}{44}} = 0.213$$

(d) Since $V_{CO_2} > V_{H_2}$, CO_2 gas molecule suffers from collision with other gas molecules more than H_2 .

Therefore U_{avg, CO_2} becomes smaller than theoretic value. Consequently, the observed $\frac{U_{avg, CO_2}}{U_{avg, H_2}}$ ratio will be smaller than 0.213 (obtained from (c)).

15% 6. (a) Le Chatelier's principle: Addition of an external factor to a balanced system will trigger the balanced system shift toward a reaction direction, so that the external factor will be canceled out.



$$K_a = \frac{[H^+][A^-]}{[HA]} \Rightarrow [H^+] = K_a \frac{[HA]}{[A^-]}$$

$$-\log[H^+] = -\log K_a - \log \frac{[HA]}{[A^-]}$$

$$\Rightarrow pH = pK_a - \log \frac{[HA]}{[A^-]}$$

$$= pK_a + \log \frac{[A^-]}{[HA]} \quad \text{--- Henderson-Hasselbalch eqn.}$$

- a. The optimum pH for a buffer is when $\text{pH} = \text{pK}_a$. At this pH a buffer will have equal neutralization capacity for both added acid and base. As shown next, because the pK_a for TRISH⁺ is 8.1, the optimal buffer pH is about 8.1.

$$K_a = 1.19 \times 10^{-8}; K_b = K_w/K_a = 8.40 \times 10^{-7}; \text{pK}_a = -\log(8.40 \times 10^{-7}) = 8.076$$

b. $\text{pH} = \text{pK}_a + \log \frac{[\text{TRIS}]}{[\text{TRISH}^+]}$, $7.00 = 8.076 + \log \frac{[\text{TRIS}]}{[\text{TRISH}^+]}$

$$\frac{[\text{TRIS}]}{[\text{TRISH}^+]} = 10^{-1.08} = 0.083 \quad (\text{at pH} = 7.00)$$

$$9.00 = 8.076 + \log \frac{[\text{TRIS}]}{[\text{TRISH}^+]}, \quad \frac{[\text{TRIS}]}{[\text{TRISH}^+]} = 10^{0.92} = 8.3 \quad (\text{at pH} = 9.00)$$

c. $\frac{50.0 \text{ g TRIS}}{2.0 \text{ L}} \times \frac{1 \text{ mol}}{121.14 \text{ g}} = 0.206 \text{ M} = 0.21 \text{ M} = [\text{TRIS}]$

$$\frac{65.0 \text{ g TRISHCl}}{2.0 \text{ L}} \times \frac{1 \text{ mol}}{157.60 \text{ g}} = 0.206 \text{ M} = 0.21 \text{ M} = [\text{TRISHCl}] = [\text{TRISH}^+]$$

$$\text{pH} = \text{pK}_a + \log \frac{[\text{TRIS}]}{[\text{TRISH}^+]} = 8.076 + \log \frac{(0.21)}{(0.21)} = 8.08$$

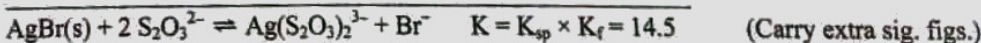
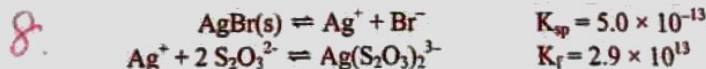
(d) The amount of H⁺ added from HCl is: $(0.50 \times 10^{-3} \text{ L}) \times 12 \text{ mol/L} = 6.0 \times 10^{-3} \text{ mol H}^+$

The H⁺ from HCl will convert TRIS into TRISH⁺. The reaction is:

	TRIS	+	H ⁺	→	TRISH ⁺	
Before	0.21 M		$\frac{6.0 \times 10^{-3}}{0.2005} = 0.030 \text{ M}$		0.21 M	
Change	-0.030		-0.030	→	+0.030	Reacts completely
After	0.18		0		0.24	

Now use the Henderson-Hasselbalch equation to solve this buffer problem.

$$\text{pH} = 8.076 + \log \left(\frac{0.18}{0.24} \right) = 7.95$$



	AgBr(s)	+	$2 \text{S}_2\text{O}_3^{2-}$	\rightleftharpoons	$\text{Ag}(\text{S}_2\text{O}_3)_2^{3-}$	+	Br^-	
Initial			0.500 M		0		0	
	$s \text{ mol/L AgBr(s) dissolves to reach equilibrium}$							
Change	-s		-2s	→	+s		+s	
Equil.			0.500 - 2s		s		s	

$$K = \frac{s^2}{(0.500 - 2s)^2} = 14.5; \text{ taking the square root of both sides:}$$

$$\frac{s}{0.500 - 2s} = 3.81, \quad s = 1.91 - (7.62)s, \quad s = 0.222 \text{ mol/L}$$

$$1.00 \text{ L} \times \frac{0.222 \text{ mol AgBr}}{\text{L}} \times \frac{187.8 \text{ g AgBr}}{\text{mol AgBr}} = 41.7 \text{ g AgBr} = 42 \text{ g AgBr}$$