

**CHEM 101+103 SECOND SEMISTER 1431-1432H  
FINAL EXAM SOLUTINS**

1. The mass in grams of platinum "Pt" that contains  $4.6 \times 10^{22}$  platinum atoms is:

- A) 14.5                      B) 14.9                      C) 13.6                      D) 12.4

**SOLUTION**

$$m = n \times M = \frac{N}{N_A} \times M = \frac{4.6 \times 10^{22}}{6.022 \times 10^{23}} \times 195.1 = 14.9 \text{ g}$$

2. The mass in grams of  $\text{Na}_3\text{N}$  that contains  $1.3 \times 10^{23}$  sodium "Na" atoms is:

- A) 6.0                      B) 7.0                      C) 8.0                      D) 9.0

**SOLUTION**

1 mol  $\text{Na}_3\text{N}$  contains 3 mol Na  
 $n$  mol  $\text{Na}_3\text{N}$  contains  $\frac{1.3 \times 10^{23}}{6.022 \times 10^{23}} = 0.216$  mol Na  
 $m = n \times M = \frac{0.216 \times 1}{3} \times 82.71 = 5.995 \text{ g}$

3. The percent by mass of phosphorous "P" in the phosphate rock  $\text{Ca}_{10}\text{F}_2(\text{PO}_4)_6$  is:

- A) 15.7                      B) 17.2                      C) 18.4                      D) 20.6

**SOLUTION**

$$\text{P}\% = \frac{M_P}{M_{\text{compound}}} \times 100 = \frac{185.82}{1008.62} \times 100 = 18.4\%$$

4. According to the following equation:



The mass in grams of HCl which can be prepared (theoretically) when reacting 150.0 g of NaCl with 150.0 g of  $\text{H}_2\text{SO}_4$  is:

- A) 79.8                      B) 100.4                      C) 85.7                      D) 93.6

**SOLUTION**

$2\text{NaCl}$	+	$\text{H}_2\text{SO}_4$	$\rightarrow$	$\text{Na}_2\text{SO}_4$	+	$2\text{HCl}$
2		1		1		2
$\frac{150}{58.44} = 2.566$		$\frac{150}{98.086} = 1.53$				n
$\frac{2.566}{2} = 1.283$		$\frac{1.53}{1} = 1.53$				n = 2.566
$m = n \times M = 2.566 \times 36.458 = 93.6 \text{ g}$						

5. The volume in ml of 0.251 M KI solution that contains 13.5 g of KI is:

- A) 324                      B) 345                      C) 363                      D) 382

**SOLUTION**

$$V = \frac{n}{C} = \frac{13.5 \div 166}{0.251} = 0.324 \text{ L} = 324 \text{ mL}$$

6. A closed gas cylinder contains exactly equal masses of the three gases CO<sub>2</sub>, N<sub>2</sub> and O<sub>2</sub>. Which one of the following statements is true?

- A) The three partial pressures for the three gases are exactly equal.  
B) The partial pressure of the CO<sub>2</sub> gas is the highest.  
C) The partial pressure of the N<sub>2</sub> gas is the highest.  
D) The partial pressure of the O<sub>2</sub> gas is the highest.

**SOLUTION**

Because " $P_i = X_i \times P_T$ ", and  $M_{\text{nitr.}} < M_{\text{oxyg.}} < M_{\text{carb.diox.}}$ ,  $X_{\text{nitr.}}$  is the highest. Consequently, N<sub>2</sub> partial pressure is the highest.

7. Which of the following pairs of gas mixtures can be most easily separated by gaseous effusion?

- A) O<sub>2</sub> and Ar    B) O<sub>2</sub> and N<sub>2</sub>    C) Ne and Ar    D) Ne and He

**SOLUTION**

As ratios between gases molar masses are wider, differences in effusion rates are wider, and separation between gases is easier. Therefore, Ne and He pair is the easier to separate

$$\text{Ar} : \text{O}_2 = 40 : 32 = 1.25$$

$$\text{O}_2 : \text{N}_2 = 32 : 28 = 1.14$$

$$\text{Ar} : \text{Ne} = 40 : 20 = 2.00$$

$$\text{Ne} : \text{He} = 40 : 4 = 4$$

8. The molecular mass (in g mol<sup>-1</sup>) of a gas for which 0.125 g occupies 93.3 mL at STP is:

- A) 44                      B) 30                      C) 71                      D) 28

**SOLUTION**

$$M = \frac{dRT}{P} = \frac{0.125 \times 0.0821 \times 273}{0.0933 \times 1} = 30 \text{ g/mol}$$

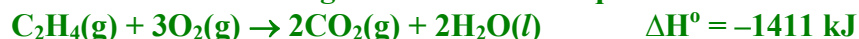
9. The amount of heat (in J) required to raise the temperature of 350.0 g of copper from 25°C to 85°C is: (the specific heat of copper is 0.385 J/g °C)

- A) 8085                      B) 7676                      C) 6806                      D) 6485

**SOLUTION**

$$q = mS\Delta T = 350 \times 0.385 \times (85 - 25) = 8085 \text{ J}$$

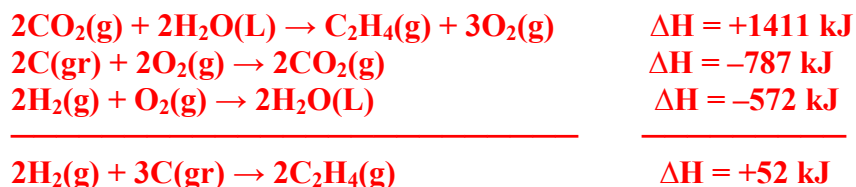
10. Given the following thermochemical equations:



The standard enthalpy of formation (in kJ) of ethylene "C<sub>2</sub>H<sub>4</sub>" is:

- A) 87                      B) -87                      C) 52                      D) -68

**SOLUTION**



11. The internal energy  $\Delta E$  ( $\Delta U$ ) of the system is always of a positive value if the system:

- A) Absorbs heat and does work.
- B) Gives off heat and does work.
- C) Gives off heat and has work done on it.
- D) Absorbs and has work done on it.

**SOLUTION**

Because  $\Delta U = q + w$ ,  $\Delta U$  will be always positive when  $q$  is positive (system absorbs heat), and  $w$  is positive (work is done on the system).

12. The molality of a 20% by mass ammonium sulfate  $(\text{NH}_4)_2\text{SO}_4$  aqueous solution is:

- A) 2.15 m      B) 1.89 m      C) 1.25 m      D) 0.87 m

**SOLUTION**

$$\text{molality} = \frac{n_2}{m_1 + m_2} = \frac{20 \div 132.154}{80 + 1000} = 1.89 \text{ molal}$$

13. What is the freezing point of an aqueous solution of a nonvolatile-nonelectrolyte solute that has a boiling point of 103.8 (for water  $K_f = 1.86$   $^\circ\text{C}/\text{m}$  and  $K_b = 0.52$   $^\circ\text{C}/\text{m}$ )?

- A)  $-13.6$   $^\circ\text{C}$       B)  $-11.2$   $^\circ\text{C}$       C)  $-9.8$   $^\circ\text{C}$       D)  $-7.7$   $^\circ\text{C}$

**SOLUTION**

$$\text{molality} = \frac{n_2}{m_1 + m_2} = \frac{20 \div 132.154}{80 + 1000} = 1.89 \text{ molal}$$

$$\text{molality} = \frac{\Delta T_b}{K_b} = \frac{3.8}{0.52} = 7.308 \text{ molal}$$

$$\Delta T_f = K_f m = 13.59$$

$$T_f = -13.59$$

14. The observed osmotic pressure (in atm) of a 0.01 M magnesium sulfate "MgSO<sub>4</sub>" solution at 25 $^\circ\text{C}$  (knowing that the van Hoff factor for MgSO<sub>4</sub> in this solution = 1.3) is:

- A) 0.488      B) 0.425      C) 0.318      D) 0.244

**SOLUTION**

$$\Pi_{\text{obs}} = i \Pi_{\text{theor}} = i \times CRT = 1.3 \times 0.01 \times 0.0832 \times 298 = 0.318 \text{ atm}$$

15. The reaction  $A + 2B \rightarrow \text{product}$  is second order in A and first order in B. Predict by what factor the rate of reaction will increase when the concentration of A is doubled and the concentration of B is tripled.

A) 6                      B) 12                      C) 9                      D) 16

**SOLUTION**

$$(\text{rate})_1 = k_1 [A]^2 [B] \quad \text{and} \quad (\text{rate})_2 = k_2 [2A]^2 [3B]$$

$$\frac{(\text{rate})_2}{(\text{rate})_1} = \frac{k \times 4 \times [A]^2 \times 3 \times [B]}{k \times [A]^2 \times [B]} = 12$$

16. The radioactive C-14 decays following first order kinetics having a rate constant =  $1.2 \times 10^{-4}$  year at  $25^\circ\text{C}$ . The half life period ( $t_{1/2}$ ) for C-14 decay rate at  $25^\circ\text{C}$  is:

A) 12000 y              B) 10858 y              C) 8985 y              D) 5775 y

**SOLUTION**

$$t_{0.5} = \frac{0.693}{k} = \frac{0.693}{1.2 \times 10^{-4}} = 5775 \text{ y}$$

17. The isomerization reaction of methyl isocyanide ( $\text{CH}_3\text{NC}$ ) follows first order kinetics. What is the slope of an Arrhenius plot knowing that the rate constant  $k = 0.29 \text{ min}^{-1}$  at 500 K and at 600 K? (the rate constant  $k = 16.3 \text{ min}^{-1}$ )

A)  $5.06 \times 10^3$       B)  $-5.06 \times 10^2$       C)  $-1.2 \times 10^4$       D)  $-8.18 \times 10^4$

**SOLUTION**

$$\ln k = \ln A - \frac{E_a}{RT} \quad , \quad \text{slope} = -\frac{E_a}{R}$$

$$\ln \frac{k_2}{k_1} = \frac{E_a}{R} \left( \frac{T_2 - T_1}{T_1 \times T_2} \right)$$

$$\ln \frac{16.3}{0.29} = \frac{E_a}{R} \left( \frac{600 - 500}{500 \times 600} \right)$$

$$\frac{E_a}{R} = 1.2 \times 10^4$$

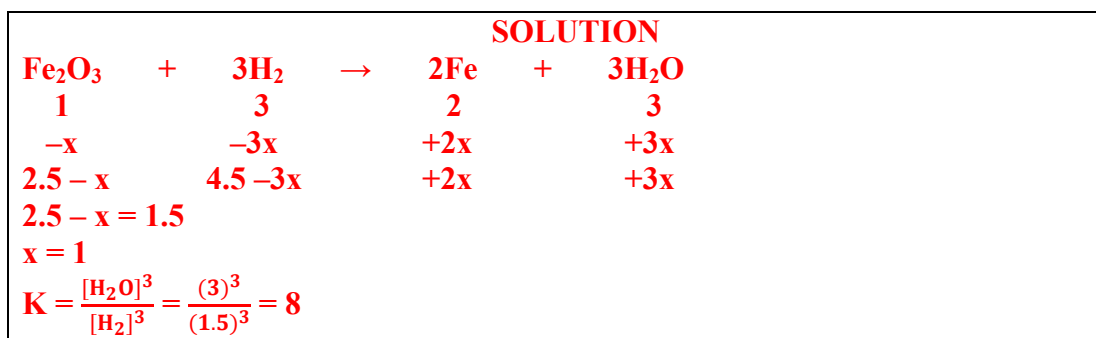
$$\text{slope} = -1.2 \times 10^4$$

18. 2.5 moles of  $\text{Fe}_2\text{O}_3$  and 4.5 moles of  $\text{H}_2$  were placed in an 1.0 L reaction vessel at  $420^\circ\text{C}$ . After the following reaction reached equilibrium, 1.5 moles of  $\text{Fe}_2\text{O}_3$  remained:



The equilibrium constant  $K_c$  for this reaction at  $420^\circ\text{C}$  is:

A) 8.0                      B) 21.3                      C) 32.0                      D) 42.6

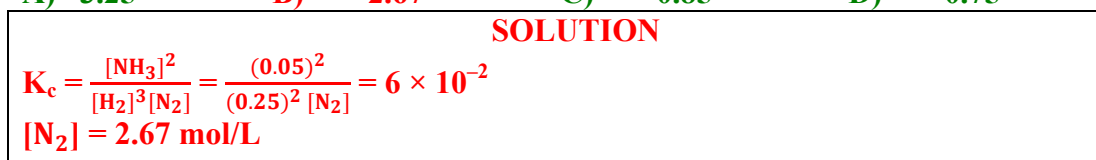


19. At temperature of  $500^\circ\text{C}$ , the equilibrium constant for the following nitrogen fixation reaction is  $K_c = 6.0 \times 10^{-2}$ :



If  $0.25 \text{ mol/L}$  of  $\text{H}_2$  and  $0.05 \text{ mol/L}$   $\text{NH}_3$  are present at equilibrium, what is the concentration of  $\text{N}_2$  (in  $\text{mol/L}$ ) at equilibrium?

- A) 3.25      B) 2.67      C) 0.85      D) 0.75



20. For the following reaction occurring at  $500 \text{ K}$ :



The equilibrium constant  $K_c$  for this reaction at  $500 \text{ K}$  is:

- A) 6.98      B) 0.69      C) 58.82      D)  $4.14 \times 10^{-4}$



21. Consider the following equilibria occurring at  $700 \text{ K}$ :



The value of the equilibrium constant  $K_{c2}$  is:

- A) 1275      B) 2085      C) 2300      D) 4600



22. For the following reaction,  $K_c = 2.5 \times 10^{-4}$  at  $100^\circ\text{C}$ .



The total gas pressure (in atm) at equilibrium is:

- A) 0.97      B) 0.84      C) 1.26      D) 1.42

**SOLUTION**

$$K_p = 2.5 \times 10^{-4} = K_c (RT)^2 = (2.5 \times 10^{-4})(0.0821 \times 373)^2 = 0.234$$

$$K_p = P_{\text{CO}_2} \times P_{\text{H}_2\text{O}}, P_{\text{CO}_2} = P_{\text{H}_2\text{O}} = (0.234)^{0.5} = 0.484 \text{ atm}$$

$$P_T = P_{\text{CO}_2} + P_{\text{H}_2\text{O}} = 2 \times 0.484 = 0.968 \text{ atm}$$

23. For the following equilibrium:



Which of the following statements is true?

- A) Higher total pressure shifts the equilibrium to the left.
- B) Higher total pressure shifts the equilibrium to the right.
- C)  $K_p$  at 1000 K is larger than  $K_p$  at 2000 K.
- D)  $K_p$  at 1000 K is less than  $K_p$  at 2000 K.

**SOLUTION**

Because number of gases' moles in both sides are equal, change in pressure will not affect equilibrium. And because the reaction is endothermic from right to left,  $K_p$  will decrease as temperature increases.

24. The conjugated acid of  $\text{NH}_2^-$  is:

- A)  $\text{NH}_4^+$
- B)  $\text{NH}_3$
- C)  $\text{HNO}_2$
- D)  $\text{HNO}_3$

**SOLUTION**

Because the conjugate acid has one  $\text{H}^+$  more than its conjugate base,  $\text{NH}_3$  is the conjugate acid of  $\text{NH}_2^-$ .

25. Lactic acid is a weak monoprotic acid that has  $K_a = 8.0 \times 10^{-4}$ . The pH value of a 0.35 M lactic acid is:

- A) 1.78
- B) 2.64
- C) 3.85
- D) 4.25

**SOLUTION**

$$[\text{H}]^+ = \sqrt{K_a C_a} = \sqrt{8 \times 10^{-4} \times 0.35} = 0.017 \text{ molar}$$

$$\text{pH} = -\log [\text{H}]^+ = -\log 0.017 = 1.78$$

26. For nitrous acid " $\text{HNO}_2$ ",  $K_a = 4.5 \times 10^{-4}$ , the  $K_b$  value for  $\text{NO}_2^-$  is:

- A)  $5.5 \times 10^{-8}$
- B)  $4.5 \times 10^{-18}$
- C)  $2.2 \times 10^{-11}$
- D)  $5.5 \times 10^{-10}$

**SOLUTION**

$$K_b = \frac{1 \times 10^{-14}}{K_a} = \frac{1 \times 10^{-14}}{4.5 \times 10^{-4}} = 2.22 \times 10^{-11}$$

27. The pH of 1.2 M ethylamine " $\text{C}_2\text{H}_5\text{NH}_2$ " (weak base) solution is 12.41. The  $K_b$  value of ethylamine is:

- A)  $4.5 \times 10^{-10}$
- B)  $1.8 \times 10^{-11}$
- C)  $1.2 \times 10^{-9}$
- D)  $5.5 \times 10^{-4}$

**SOLUTION**

$$\text{pOH} = 14 - \text{pH} = 14 - 12.41 = 1.59, [\text{OH}^{-1}] = 0.0257 \text{ molar}$$
$$[\text{OH}^{-1}] = 0.0257 = \sqrt{K_b C_b} = \sqrt{K_b \times 1.2}, K_b = 5.5 \times 10^{-4}$$

28.  $K_a$  for acetic acid " $\text{CH}_3\text{COOH}$ " =  $1.8 \times 10^{-5}$ . In which one of the following solutions will acetic acid have the greatest degree of ionization:

- A) 0.1 M  $\text{CH}_3\text{COOH}$ .  
B) 0.1 M  $\text{CH}_3\text{COOH}$  plus 0.1 M HCl.  
C) 0.1 M  $\text{CH}_3\text{COOH}$  plus 0.1 M  $\text{CH}_3\text{COONa}$ .  
D) 0.1 M  $\text{CH}_3\text{COOH}$  plus 0.2 M  $\text{CH}_3\text{COONa}$ .

**SOLUTION**



Solution in choice B contains more  $\text{H}_3\text{O}^{+}$  than solution in A, and solutions in choices C and D contains more  $\text{CH}_3\text{COO}^{-}$  than solution in A. All of that shifts equilibrium position toward left, which in turn decreases the ionization degree of  $\text{CH}_3\text{COOH}$ . Therefore acetic acid in choice A has the greatest degree of ionization.

29. The pH value of  $8.5 \times 10^{-2}$  M NaOH "strong base" solution is:

- A) 1.07                      B) 0.77                      C) 12.93                      D) 10.23

**SOLUTION**

$$[\text{OH}^{-1}] = n C_b = 1 \times 8.5 \times 10^{-2} = 8.5 \times 10^{-2} \text{ molar}$$
$$\text{pOH} = -\log 8.5 \times 10^{-2} = 1.07, \text{pH} = 14 - 1.07 = 12.93$$

30. Calculate the pH of a buffer solution that is prepared by dissolving 0.4 mol of ammonia " $\text{NH}_3$ " and 0.6 mol ammonium chloride " $\text{NH}_4\text{Cl}$ " in enough water to make 500 mL of solution ( $K_b \text{ NH}_3 = 1.8 \times 10^{-5}$ ):

- A) 4.9                      B) 9.1                      C) 10.3                      D) 3.7

**SOLUTION**

$$[\text{NH}_3] = \frac{n_2}{v} = \frac{0.4}{0.5} = 0.8 \text{ molar}, \quad [\text{NH}_4^{+}] = \frac{n_2}{v} = \frac{0.6}{0.5} = 1.2 \text{ molar}$$
$$\text{pOH} = \text{p}K_b + \log \frac{[\text{salt}]}{[\text{base}]} = 4.74 + \log \frac{1.2}{0.8} = 4.92$$
$$\text{pH} = 14 - 4.92 = 9.08$$