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

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

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

   SOLUTION

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

2. The mass in grams of Na_3N that contains 1.3×10^{23} sodium "Na" atoms is:

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

   SOLUTION

   1 mol Na_3N contains 3 mol Na

   n mol Na_3N contains $\frac{1.3 \text{ x } 10^{23}}{6.022 \text{ x } 10^{23}} = 0.216$ 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 $Ca_{10}F_2(PO_4)_6$ is:

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

   SOLUTION

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

4. According to the following equation:
   $2NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2HCl$
   The mass in grams of HCl which can be prepared (theoretically) when reacting 150.0 g of NaCl with 150.0 g of H_2SO_4 is:

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

   SOLUTION

$2NaCl$	+	H_2SO_4	$\rightarrow$	Na_2SO_4	+	$2HCl$
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

   $$V = \frac{n}{C} \quad \frac{13.5 \div 166}{58.44} = 0.324 \text{ L} = 324 \text{ mL}$$

6. A closed gas cylinder contains exactly equal masses of the three gases CO_2, N_2 and O_2. 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_2 gas is the highest.
C) The partial pressure of the N_2 gas is the highest.
D) The partial pressure of the O_2 gas is the highest.

SOLUTION

Because "$P_i = X_i \times P_T$", and $M_{nitr.} < M_{oxyg.} < M_{carb.diox.}$, $X_{nitr.}$ is the highest. Consequently, N_2 partial pressure is the highest.

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

A) O_2 and Ar B) O_2 and N_2 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

Ar : O_2 = 40 : 32 = 1.25
O_2 : N_2 = 32 : 28 = 1.14
Ar : Ne = 40 : 20 = 2.00
Ne : He = 40 : 4 = 4

8. The molecular mass (in g mol^{-1}) 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

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

10. Given the following thermochemical equations:

$C_2H_4(g) + 3O_2(g) \rightarrow 2CO_2(g) + 2H_2O(l)$ $\Delta H^o = -1411$ kJ
$C\ (gr) + O_2(g) \rightarrow CO_2(g)$ $\Delta H^o = -393.5$ kJ
$H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ $\Delta H^o = -286$ kJ

The standard enthalpy of formation (in kJ) of ethylene "C_2H_4" is:

A) 87 B) –87 C) 52 D) –68

SOLUTION

$2CO_2(g) + 2H_2O(L) \rightarrow C_2H_4(g) + 3O_2(g)$	$\Delta H = +1411$ kJ
$2C(gr) + 2O_2(g) \rightarrow 2CO_2(g)$	$\Delta H = -787$ kJ
$2H_2(g) + O_2(g) \rightarrow 2H_2O(L)$	$\Delta H = -572$ kJ
$2H_2(g) + 3C(gr) \rightarrow 2C_2H_4(g)$	$\Delta H = +52$ kJ

11. The internal energy □E (□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 $\Delta U = q + w$, ΔU 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 $(NH_4)_2SO_4$ 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 $K_f = 1.86$ $^oC/m$ and $K_b = 0.52$ $^oC/m$)?

A) -13.6 ^oC B) -11.2 ^oC C) -9.8 ^oC D) -7.7 ^oC

SOLUTION

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

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

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

$$T_f = -13.59\ ^oC$$

14. The observed osmotic pressure (in atm) of a 0.01 M magnesium sulfate "$MgSO_4$" solution at 25^{o}C (knowing that the van Hoff factor for $MgSO_4$ in this solution = 1.3) is:

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

SOLUTION

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

15. The reaction $A + 2B \rightarrow$ 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

$(rate)_1 = k_1 [A]^2[B]$ and $(rate)_2 = k_2 [2A]^2[3B]$

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

16. The radioactive C-14 decays following first order kinetics having a rate constant = 1.2×10^{-4} year at 25^oC. The half life period ($t_{1/2}$) for C-14 decay rate at 25^oC 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 (CH_3NC) follows first order kinetics. What is the slope of an Arhenius plot knowing that the rate constant k = 0.29 min^{-1} at 500 K and at 600 K? (the rate constant k = 16.3 min^{-1})

A) 5.06×10^3 B) -5.06×10^2 C) -1.2×10^4 D) -8.18×10^4

SOLUTION

$\ln k = \ln A - \frac{E_a}{RT}$, 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 Fe_2O_3 and 4.5 moles of H_2 were placed in an 1.0 L reaction vessel at 420^oC. After the following reaction reached equilibrium, 1.5 moles of Fe_2O_3 remained:

$$Fe_2O_3(s) + 3H_2(g) \rightleftharpoons 2Fe(s) + 3H_2O(g)$$

The equilibrium constant K_c for this reaction at 420^oC is:

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

SOLUTION

Fe_2O_3	+	$3H_2$	→	2Fe	+	$3H_2O$
1		3		2		3
–x		–3x		+2x		+3x
2.5 – x		4.5 –3x		+2x		+3x

2.5 – x = 1.5

x = 1

$K = \frac{[H_2O]^3}{[H_2]^3} = \frac{(3)^3}{(1.5)^3} = 8$

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

$$3H_2(g) + N_2(g) \rightleftharpoons 2NH_3(g)$$

If 0.25 mol/L of H_2 and 0.05 mol/L NH_3 are present at equilibrium, what is the concentration of N_2 (in mol/L) at equilibrium?

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

SOLUTION

$K_c = \frac{[NH_3]^2}{[H_2]^3[N_2]} = \frac{(0.05)^2}{(0.25)^2\,[N_2]} = 6 \times 10^{-2}$

$[N_2]$ = 2.67 mol/L

20. For the following reaction occurring at 500 K:

$$2NOCl(g) \rightleftharpoons 2NO(g) + Cl_2(g) \qquad K_p = 1.7 \times 10^{-2}$$

The equilibrium constant K_c for this reaction at 500 K is:

A) 6.98 B) 0.69 C) 58.82 D) 4.14×10^{-4}

SOLUTION

$K_c = K_p\,(RT)^{-\Delta n_g} = 1.7 \times 10^{-2} \times (0.0821\ \ 500) = 4.4 \times 10^{-4}$

21. Consider the following equilibria occurring at 700 K:

$2SO_3(g) \rightleftharpoons 2SO_2(g) + O_2(g) \qquad K_{c1} = 2.3 \times 10^{-7}$

$SO_2(g) + ½O_2(g) \rightleftharpoons SO_3(g) \qquad K_{c2} = ?$

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

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

SOLUTION

$K_{c2} = \frac{1}{K_{c1})^{0.5}} = \frac{1}{(2.3 \times 10^{-7})^{0.5}} = 2085$

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

$2NaHCO_3(s) \rightleftharpoons Na_2CO_3(s) + CO_2(g) + H_2O(g)$

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

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

SOLUTION

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

$K_p = P_{CO_2} \times P_{H_2O}$, $P_{CO_2} = P_{H_2O} = (0.234)^{0.5} = 0.484$ atm

$P_T = P_{CO_2} + P_{H_2O} = 2 \times 0.484 = 0.968$ atm

23. For the following equilibrium:

$2NO(g) \rightleftharpoons N_2(g) + O_2(g) \qquad \Delta H^o = -180$ kJ

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 NH_2^- is:

A) NH_4^+ B) NH_3 C) HNO_2 D) HNO_3

SOLUTION

Because the conjugate acid has one H^+ more than its conjugate base, NH_3 is the conjugate acid of NH_2^{-1}.

25. Lactic acid is a weak monoprotic acid that has $K_a = 8.0\times10^{-4}$. The pH value of a 0.35 M lactic acid is:

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

SOLUTION

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

pH = -log $[H]^+$ = -log 0.017 = 1.78

26. For nitrous acid "HNO_2", $K_a = 4.5\times10^{-4}$, the K_b value for NO_2^- is:

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

SOLUTION

$K_b = \frac{1\times10^{-14}}{K_a} = \frac{1\times10^{-14}}{4.5\times10^{-4}} = 2.22 \times 10^{-11}$

27. The pH of 1.2 M ethylamine "$C_2H_5NH_2$" (weak base) solution is 12.41. The K_b value of ethylamine is:

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

SOLUTION

$pOH = 14 – pH = 14 – 12.41 = 1.59$, $[OH^{-1}] = 0.0257$ molar

$[OH^{-1}] = 0.0257 = \sqrt{K_b\, C_b} = \sqrt{K_b \times 1.2}$, $K_b = 5.5 \times 10^{-4}$

28. K_a for acetic acid "CH_3COOH" = 1.8×10^{-5}. In which one of the following solutions will acetic acid have the greatest degree of ionization:

A) 0.1 M CH_3COOH.
B) 0.1 M CH_3COOH plus 0.1 M HCl.
C) 0.1 M CH_3COOH plus 0.1 M CH_3COONa.
D) 0.1 M CH_3COOH plus 0.2 M CH_3COONa.

SOLUTION

$$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$$

Solution in choice B contains more H_3O^+ than solution in A, and solutions in choices C and D contains more CH_3COO^- than solution in A. All of that shifts equilibrium position toward left, which in turn decreases the ionization degree of CH_3COOH. Therefore acetic acid in choice A has the greatest degree of ionization.

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

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

SOLUTION

$[OH^{-1}] = n\, C_b = 1 \times 8.5 \times 10^{-2} = 8.5 \times 10^{-2}$ molar

$pOH = –\log 8.5 \times 10^{-2} = 1.07$, $pH = 14 – 1.07 = 12.93$

30. Calculate the pH of a buffer solution that is prepared by dissolving 0.4 mol of ammonia "NH_3" and 0.6 mol ammonium chloride "NH_4Cl" in enough water to make 500 mL of solution (K_b $NH_3 = 1.8\times10^{-5}$):

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

SOLUTION

$[NH_3] = \frac{n_2}{V} = \frac{0.4}{0.5} = 0.8$ molar , $[NH_4^+] = \frac{n_2}{V} = \frac{0.6}{0.5} = 1.2$ molar

$pOH = pK_a + \log\frac{[salt]}{[base]} = 1.8 \times 10^{-5} + \frac{1.2}{0.8} = 4.92$

$pH = 14 – 4.92 = 9.08$