

FORMULA SHEET (tear off)

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|-------------------|-------------------|--------------------|--------------------|--------------------|--------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--------------------|--------------------|--------------------|-------------------|-------------------|-------------------|-------------------|--|--|
| 1A | | | | | | | | | | 8A | | | | | | | | | |
| 1 H 1.01 | 2A | | | | | | | | | | 3A | 4A | 5A | 6A | 7A | 2 He 4.00 | | | |
| 3 Li 6.94 | 4 Be 9.01 | | | | | | | | | | | 5 B 10.81 | 6 C 12.01 | 7 N 14.01 | 8 O 16.00 | 9 F 19.00 | 10 Ne 20.18 | | |
| 11 Na 22.99 | 12 Mg 24.31 | | | | | | | | | | | 13 Al 26.98 | 14 Si 28.09 | 15 P 30.97 | 16 S 32.07 | 17 Cl 35.45 | 18 Ar 39.95 | | |
| 19 K 39.10 | 20 Ca 40.08 | 21 Sc 44.96 | 22 Ti 47.87 | 23 V 50.94 | 24 Cr 52.00 | 25 Mn 54.94 | 26 Fe 55.85 | 27 Co 58.93 | 28 Ni 58.69 | 29 Cu 63.55 | 30 Zn 65.41 | 31 Ga 69.72 | 32 Ge 72.64 | 33 As 74.92 | 34 Se 78.96 | 35 Br 79.90 | 36 Kr 83.80 | | |
| 37 Rb 85.47 | 38 Sr 87.62 | 39 Y 88.91 | 40 Zr 91.22 | 41 Nb 92.91 | 42 Mo 95.94 | 43 Tc [98] | 44 Ru 101.1 | 45 Rh 102.9 | 46 Pd 106.4 | 47 Ag 107.9 | 48 Cd 112.4 | 49 In 114.8 | 50 Sn 118.7 | 51 Sb 121.8 | 52 Te 127.6 | 53 I 126.9 | 54 Xe 131.3 | | |
| 55 Cs 132.9 | 56 Ba 137.3 | 71 Lu 175.0 | 72 Hf 178.5 | 73 Ta 181.0 | 74 W 183.8 | 75 Re 186.2 | 76 Os 190.2 | 77 Ir 192.2 | 78 Pt 195.1 | 79 Au 197.0 | 80 Hg 200.6 | 81 Tl 204.4 | 82 Pb 207.2 | 83 Bi 209.0 | 84 Po [209] | 85 At [210] | 86 Rn [222] | | |
| 87 Fr [223] | 88 Ra [226] | 103 Lr [262] | 104 Rf [261] | 105 Db [262] | 106 Sg [266] | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| 57 La 138.9 | 58 Ce 140.1 | 59 Pr 140.9 | 60 Nd 144.2 | 61 Pm [145] | 62 Sm 150.4 | 63 Eu 152.0 | 64 Gd 157.2 | 65 Tb 158.9 | 66 Dy 162.5 | 67 Ho 164.9 | 68 Er 167.3 | 69 Tm 168.9 | 70 Yb 173.0 | | | | | | |
| 89 Ac [227] | 90 Th 232.0 | 91 Pa 231.0 | 92 U 238.0 | 93 Np [237] | 94 Pu [244] | 95 Am [243] | 96 Cm [247] | 97 Bk [247] | 98 Cf [251] | 99 Es [252] | 100 Fm [257] | 101 Md [258] | 102 No [259] | | | | | | |

$$N_A = 6.022 \times 10^{23}$$

$$1 \text{ amu} = 1.661 \times 10^{-27} \text{ kg}$$

$$1 \text{ atm} = 760 \text{ torr} = 760 \text{ mm Hg}$$

$$R = 0.08206 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K}$$

$$R = 8.314 \text{ J}/\text{mol}\cdot\text{K}$$

$$F = 96485 \text{ C}/\text{mol}$$

$$^{\circ}\text{C} = (5/9)(^{\circ}\text{F} - 32)$$

$$^{\circ}\text{C} = \text{K} - 273.15$$

$$1 \text{ atm} = 1.013 \text{ bar}$$

$$1 \text{ L}\cdot\text{atm} = 101.3 \text{ J}$$

$$1 \text{ J} = 1 \text{ kg}\cdot\text{m}^2/\text{s}^2$$

$$^{\circ}\text{F} = (9/5)(^{\circ}\text{C}) + 32$$

$$\text{K} = ^{\circ}\text{C} + 273.15$$

$$pV = nRT$$

$$p_A = X_A p_A^{\circ}$$

$$\Delta T_b = K_b m_B$$

$$H = U + pV$$

$$\Delta G_{\text{rxn}} = \Delta G^{\circ}_{\text{rxn}} + RT \ln Q$$

$$\text{If } ax^2 + bx + c = 0, \text{ then } x = \left(\frac{-b \pm [b^2 - 4ac]^{1/2}}{2a} \right)$$

$$K_a \cdot K_b = K_w$$

$$K_a \cdot K_b = 1.0 \times 10^{-14} \text{ (at } T = 25. ^{\circ}\text{C)}$$

$$\Delta G = -nFE_{\text{cell}}$$

$$[A]_t = [A]_0 e^{-kt}$$

$$[A]_t = \frac{[A]_0}{(1 + kt[A]_0)}$$

$$k = A e^{-E_a/RT}$$

$$[B] = k p_B$$

$$\Delta T_f = K_f m_B$$

$$G = H - TS$$

$$\ln K = -\frac{\Delta G^{\circ}_{\text{rxn}}}{RT}$$

$$E_{\text{cell}} = E^{\circ}_{\text{cell}} - (RT/nF) \ln Q$$

$$\ln[A]_t = \ln[A]_0 - kt$$

$$\frac{1}{[A]_t} = \frac{1}{[A]_0} + kt$$

$$\ln k = \ln A - (E_a/R)(1/T)$$

$$\Delta p_A = X_B p_A^{\circ}$$

$$\Pi = M_B RT$$

$$K_p = K_C (RT)^{\Delta n_g}$$

$$\ln K = \frac{nFE^{\circ}_{\text{cell}}}{RT}$$

$$t_{1/2} = (\ln 2)/k$$

$$t_{1/2} = 1/(k[A]_0)$$

$$\ln(k_2/k_1) = - (E_a/R) [(1/T_2) - (1/T_1)]$$

$$pH + pOH = pK_w$$

$$pH + pOH = 14.00 \text{ (at } T = 25. ^{\circ}\text{C)}$$

**GENERAL CHEMISTRY 2
FINAL EXAM
DECEMBER 6, 2021**

Name _____

Panthersoft ID _____

Signature _____

Part 1 _____ (45 points)

Part 2 _____ (87 points)

Part 3 _____ (68 points)

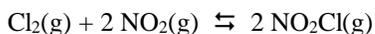
TOTAL _____ (100 points)

Do all of the following problems. Show your work.
Unless otherwise stated, you may assume T = 25. °C in all problems.

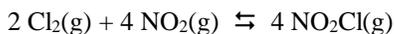
Part 1. Multiple choice. Circle the letter corresponding to the correct answer. There is one and only one correct answer per problem. [5 points each]

- 1) When a non-volatile solute is dissolved in a volatile liquid
- a) the boiling point temperature of the liquid increases
 - b) the freezing point temperature of the liquid increases
 - c) the vapor pressure of the liquid increases
 - d) both a and b
 - e) both a and b and c
- 2) For which of the following substances is $S^\circ = 0.00 \text{ J/mol}\cdot\text{K}$ at $T = 25.0 \text{ }^\circ\text{C}$?
- a) Cu(s)
 - b) O₂(g)
 - c) CuO(s)
 - d) Both a and b
 - e) None of the above

- 3) The numerical value for the equilibrium constant for the reaction



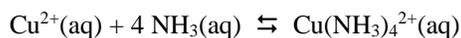
is $K_C = 3.8$ at a particular temperature. The equilibrium constant for the reaction



measured at the same temperature is

- a) 0.13
 - b) 3.8
 - c) 7.6
 - d) 14.4
 - e) Cannot be determined from the information given
- 4) For a spontaneous chemical reaction for standard conditions which of the following must be true?
- a) $\Delta G^\circ_{\text{rxn}} < 0$
 - b) $\Delta H^\circ_{\text{rxn}} < 0$
 - c) $\Delta S^\circ_{\text{rxn}} < 0$
 - d) Both a and c
 - e) Both a and b and c
- 5) A Bronsted base
- a) is a proton donor
 - b) is a proton acceptor
 - c) is an electron pair donor
 - d) is an electron pair acceptor
 - e) none of the above

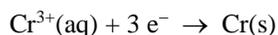
6) The reaction



is an example of

- a) an Arrhenius acid-base reaction
- b) a Bronsted acid-base reaction
- c) a Lewis acid-base reaction
- d) Both b and c
- e) Both a and b and c

7) The half-cell potential for the reaction



is $E^\circ = -0.74 \text{ v}$. The half-cell potential for the reaction



is

- a) + 0.74 v
- b) - 0.74 v
- c) + 1.48 v
- d) - 1.48 v
- e) 0.00 v

8) A particular chemical reaction follows the rate law

$$\text{rate} = k [\text{A}] [\text{B}]^2$$

The concentration of A is doubled, and the concentration of B is tripled. The new rate of reaction will be

- a) the same as the old rate of reaction
- b) 2 times the old rate of reaction
- c) 6 times the old rate of reaction
- d) 18 times the old rate of reaction
- e) 36 times the old rate of reaction

9) According to collision theory, which of the following must occur for a chemical reaction to take place?

- a) There must be a collision between the two molecules that are reacting
- b) There must be sufficient energy in the collision to overcome the energy barrier separating reactants from products
- c) The collision must have a favorable orientation between the reactant molecules
- d) Both a and b
- e) Both a and b and c

Part 2. Short answer.

1) A solution is prepared by dissolving 0.1786 g of barium chloride (BaCl_2 , MW = 208.2 g/mol) in water. The final volume of the solution is $V = 200.0$ mL. What is the molarity of barium chloride in the solution? [12 points]

2) For a particular chemical reaction it is found that $\Delta S^\circ_{\text{rxn}} = -14.6$ J/mol·K. Is it possible that the reaction is spontaneous for standard conditions (yes or no, plus a brief justification of your answer)? [8 points]

3) Give the conjugate acid and the conjugate base for the HPO_4^{2-} ion (correct formula and charge). [4 points each]

conjugate acid _____

conjugate base _____

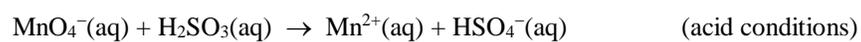
4) Cyanide ion (CN^-) will interact with a variety of different metal cations. One example of this is the following reaction:



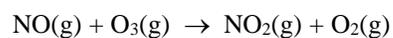
A system initially contains 0.00240 M $\text{Ni}(\text{CN})_4^{2-}$, 0.0428 M $\text{Ni}^{2+}(\text{aq})$, and 0.0138 M $\text{Ag}(\text{CN})_2^-$. There is initially no Ag^+ present in the system. Set up an appropriate ICE table for the above system. NOTE: You are not given a numerical value for K_C , the equilibrium constant for the reaction, so only set up the ICE table. [12 points]

5) The concentration of magnesium ion in an aqueous solution is $[\text{Mg}^{2+}] = 4.6 \times 10^{-4}$ M. At what value for pH will magnesium hydroxide first begin to precipitate from the solution? Note that the solubility product for magnesium hydroxide ($\text{Mg}(\text{OH})_2$) is $K_{\text{sp}} = 5.6 \times 10^{-12}$. [12 points]

6) Balance the following unbalanced oxidation-reduction reaction for acid conditions. [15 points]



7) The activation energy and pre-exponential factor for the rate constant for the reaction



are $E_a = 12470. \text{ J/mol}$ and $A = 1.8 \times 10^9 \text{ L/mol}\cdot\text{s}$. Based on this, find the numerical value for k at $T = 240. \text{ K}$ (including correct units). [12 points]

8) Define the word catalyst. [8 points]

Part 3. Problems.

1) Thermodynamic data are given below (at $T = 25. \text{ }^\circ\text{C}$) and may be of use in doing this problem.

| Substance | $\Delta H_f^\circ(\text{kJ/mole})$ | $\Delta G_f^\circ(\text{kJ/mole})$ | $S^\circ(\text{J/mole}\cdot\text{K})$ |
|-------------------------|------------------------------------|------------------------------------|---------------------------------------|
| $\text{I}_2(\text{s})$ | 0.0 | 0.0 | 116.1 |
| $\text{IF}(\text{g})$ | - 95.7 | - 118.5 | 236.2 |
| $\text{IF}_5(\text{g})$ | - 822.5 | - 751.7 | 327.7 |

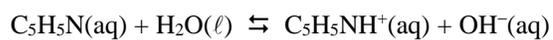
a) What are $\Delta S^\circ_{\text{rxn}}$ and $\Delta G^\circ_{\text{rxn}}$ for the reaction



at $T = 25. \text{ }^\circ\text{C}$ (including units)? [15 points]

b) What is the numerical value for K , the equilibrium constant, for the above reaction? [12 points]

2) Pyridine (C_5H_5N , MW = 79.10 g/mol) is a weak base. When added to water it reacts by the process



The base ionization constant for pyridine is $K_b = 1.8 \times 10^{-9}$

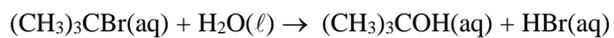
a) In the above reaction, is $H_2O(\ell)$ a Bronsted acid or a Bronsted base (circle the correct answer)?
[5 points]

Bronsted acid

Bronsted base

b) A chemist prepares a 0.0428 M solution of pyridine. What is the pH of the solution? [16 points]

3) The irreversible chemical reaction of tert-butyl bromide ((CH₃)₃CBr) in water



follows a first order rate law $\text{rate} = k [(\text{CH}_3)_3\text{CBr}]$; with $k = 5.2 \times 10^{-4} \text{ s}^{-1}$ at $T = 25.0 \text{ }^\circ\text{C}$.

a) What is the value for $t_{1/2}$, the half-life for the above reaction? Give your final answer in units of minutes.
[8 points]

b) In a particular experiment at $T = 25.0 \text{ }^\circ\text{C}$, the initial concentration of tert-butyl bromide is $[(\text{CH}_3)_3\text{CBr}]_0 = 3.66 \times 10^{-3} \text{ M}$. What will be the concentration of tert-butyl bromide after 1 hour? [12 points]