

# SENIOR CHEMISTRY – A STUDY GUIDE

## 1. THERMODYNAMICS

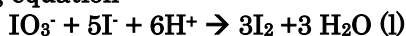
- endo & exo thermic reactions → recognize them → write  $\Delta H$  term
- Hess' Law → adding equations & adding their  $\Delta H$  terms
- $Q = mc\Delta T$        $\Delta H = Q/n$
- $\Delta H = \sum \Delta H(\text{form}) \text{ products} - \sum \Delta H(\text{form}) \text{ reactants}$

1. 7.46 g of potassium chloride is dissolved in 100.0 ml of water at an initial temperature of 24.1°C. The final temperature of the solution is 20.0°C. What is the molar enthalpy of solution of potassium chloride?
2. Calculate  $\Delta H^\circ$  for the following
  - i)  $\text{N}_2\text{O}(\text{g}) + \text{O}_2(\text{g}) \rightarrow \text{NO}(\text{g}) + \text{NO}_2(\text{g})$
  - ii) the combustion of butane to produce liquid water

## 2. KINETICS

- Collision Theory
- Factors affecting the rate of a reaction
- Rate expressions    ie rate =  $k[\text{A}]^1[\text{B}]^2$  (1<sup>st</sup> order & second order etc)
- 1<sup>st</sup> order decay      →  $\ln [\text{A}]_0 / [\text{A}]_t = kt$  → 1/2 life
- activation energy
- Energy profile diagrams

3. a) Write the rate law for the following equation:



If  $[\text{IO}_3^-]$  is doubled the rate doubles

If  $[\text{I}^-]$  is doubled the rate doubles

If  $[\text{H}^+]$  is doubled the rate quadruples

- i)  $[\text{IO}_3^-]$  &  $[\text{I}^-]$  are doubled .....
- ii)  $[\text{IO}_3^-]$  is halved &  $[\text{H}^+]$  is x 0.5 .....

4. When  $\text{SO}_2$  and  $\text{O}_2$  are reacted together in the presence of vanadium pentoxide, an intermediate  $[(\text{V}_2\text{O}_5) \cdot (\text{SO}_2)_2(\text{O}_2)]$  is formed with an  $E_a = 335 \text{ kJ}$ . This intermediate then decomposes into sulfur trioxide and vanadium pentoxide with a  $\Delta H = -535 \text{ kJ}$ .
  - i) Draw a labelled energy profile diagram to portray this reaction data.
5. A first order reaction  $\text{X} \rightarrow \text{B}$  has a 1/2 life of 2 hours and starts with a concentration of X at 0.04 M. After 2 hours the molarity has dropped to 0.02 M.
  - a) What is the concentration of X after 3 hours ?

## 3. EQUILIBRIUM I

- Characteristics
- LeChatalier principle    stress = concentration/temp/pressure      → make predictions
- $K_e = \frac{[\text{prod}]^p}{[\text{react}]^r}$        $K_{e1} = K_{e1}^2$  (if rx is written with all exp doubled)

6. How will the equilibrium  $\text{CH}_4 + 2\text{H}_2\text{S} \rightarrow \text{CS}_2 + 4\text{H}_2$      $\Delta H = +46 \text{ kJ}$  be affected by
  - i) the addition of  $\text{CH}_4$
  - ii) additional  $\text{H}_2$
  - iii) removal of  $\text{CS}_2$
  - iv) a decrease in volume
7. At a certain temp the rx \*  $\text{CH}_3\text{OH} + \text{CH}_3\text{COOH} \rightarrow \text{CH}_3\text{COO}-\text{CH}_3 + \text{H}_2\text{O}(\text{l})$  has a  $K_e = 0.5$ . At eq'm the  $[\text{CH}_3\text{OH}]$  was measured at 0.210 M and  $[\text{CH}_3\text{COOH}]$  at 0.1 M
  - a) what is the  $[\text{CH}_3\text{COO}-\text{CH}_3]$  at eq'm?
8. Consider  $\text{P}_2 + 2\text{B}_2 \rightarrow 2\text{PB}_2$   
0.2 mol of  $\text{P}_2$  & 0.3 mol of  $\text{B}_2$  are mixed in a 500 mL container. At EQ'M  $[\text{PB}_2] = 0.15 \text{ M}$ . Calculate the  $K_e$  value for this reaction.
9. If a 500 mL container had 1 mole of XY placed into it and allowed to reach eq'm according to this equation\*  
 $\text{X}_2 + \text{Y}_2 \rightarrow 2\text{XY}$      $K_e = 9.0$ . What would the eq'm concentration of all substances be ?

## 4. EQUILIBRIUM II

- $K_{sp} = [\text{ion \#1}]^x [\text{ion \#2}]^y$  for heterogeneous equilibria (no reactant on the bottom – it's a solid)
- The common ion effect
- Will a precipitate form ?? - if  $K_{sp}$  has been reached  $\rightarrow$  yes (ie. finding Q)

10. The molar solubility of  $M_3PO_4$  is  $1.5 \times 10^{-3}$  @  $20^\circ C$ . Calculate the  $K_{sp}$  value for this compound
11. The solubility of silver carbonate is  $2.45 \times 10^{-4}$  g/100 mL @  $25^\circ C$ , calculate its  $K_{sp}$  value.
12. a) Calculate the solubility of aluminum hydroxide.  
b) Calculate the solubility of chromic hydroxide.
13. If you combine 60 mL of 0.02M  $TiNO_3$  & 40 mL of 0.01 M  $CaCl_2$ , will a ppt form? ( $K_{sp} = 1.9 \times 10^{-4}$  -  $TiCl$ )
14. Calculate the pH of a saturated solution of  $Mg(OH)_2$  !

## 5. EQUILIBRIUM III

- pH concept                      pOH concept                       $K_w$  concept (role of water in acid/base equilibria)
- $K_a = \frac{[H^+][A^-]}{[HA]}$                        $K_b = \frac{[H^+][OH^-]}{[HOH]}$                        $K_w = [H^+][OH^-]$
- $pH + pOH = 14$
- conjugate acid base pairs ( strong acid has conjugate weak base)
- Lowry-Bronsted acid & bases                      Lewis acids & bases
- buffers

15. Calculate the pH of    i)  $5.4 \times 10^{-3}$  M HCl                      ii) 0.05 M NaOH  
                                  iii) 0.15 M HCOOH                      iv) 0.9 M  $HC_2H_3O_2$   
                                  v) 40 mL of 0.02 M HCl mixed with 20 mL of 0.03 M NaOH
16. Calculate the  $[H^+]$  in    i) sol'n with  $pH=4.66$     ii) sol'n having  $pOH=2.81$
17. What is the pH and % dissociation in a 0.15 M sol'n of hydrofluoric acid ?
18. A 1.0 L buffer is prepared from 0.25 mol of acetic acid and 0.25 mol of sodium acetate. Calculate the change in pH if 0.15 mol of  $OH^-$  is formed in the buffer.
19. Complete the following acid/base equations and identify the acid-base pairs.  
          i)  $SO_4^{2-} + NH_4^+ \rightarrow$     ii)  $F^- + HClO \rightarrow$                       iii)  $\rightarrow H_3O^+ + ClO_4^-$

## 6. Electrochemistry

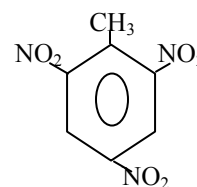
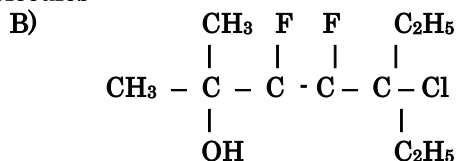
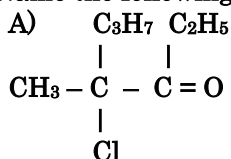
- oxidation numbers
- balancing redox equations with oxidation numbers & half-reactions
- galvanic cells  $\rightarrow$  anode: oxidation (loss of electrons) always takes place here  
 $\rightarrow$  cathode: reduction (gain of electrons) always takes place here
- Finding  $E^\circ$                       ( $E^\circ = +ve \# \rightarrow$  spontaneous)  
 $E^\circ = E^\circ_{cat} - E^\circ_{an}$  \*remember to change signs!
- electrolysis  $\rightarrow$  electrolytic cell
- quantitative electrolysis                       $Q = IT$   
 $n_e = Q/F = IT/F$

20. Draw a fully labelled  $Cr/Cr^{3+}/Pb^{2+}/Pb$  electrochemical cell. Include the rx eq'n,  $E^\circ$ , &  $\Delta G^\circ$   
b) Calculate the cell potential if  $[Cr^{3+}] = 2.4 \times 10^{-5}$  &  $[Pb^{2+}] = 9.6 \times 10^{-1}$
21. A sample of  $Pd^{2+}$  has a current of 500 amps applied to it for 4 h. How many grams of Pd will plate out?
22. Balance the following using oxidation numbers  
i)  $Mn^{2+} + HBiO_3 + \rightarrow Bi^{3+} + MnO_4^-$  (acidic)  
ii)  $Cr_2(SO_4)_3 + Na_2CO_3 + KNO_3 \rightarrow Na_2CrO_4 + KNO_2 + Na_2SO_4 + CO_2$
23. Balance the following using half-reaction method.  
i)  $Cl_2 + SO_2 \rightarrow Cl^- + SO_4^{2-}$  (acidic)  
ii)  $MnO_4^- + I^- \rightarrow MnO_2 + I_2$  (basic)

## 7. Organic Chemistry

- nomenclature
  - alkanes
  - alkenes
  - alkynes
  - halides
  - benzene & its derivatives
  - functional groups
    - alcohols ( C-OH → "ol")
    - ethers ( C-O-C → "yl" "yl" ether)
    - aldehydes ( CH=O → "al")
    - ketones ( C-CO-C → "one")
    - carboxylic acids ( COOH → "ic acid")
    - esters ( COO-C → "oate")
    - amines ( C-NH<sub>2</sub> )
- Organic reactions
  - substitution
  - addition
  - elimination
  - esterification / hydrolysis
  - dehydration
  - hydration

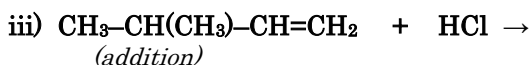
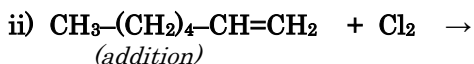
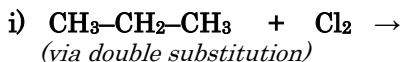
31. Name the following organic molecules



32. Draw complete structural formula for :

- A) 2,3-dicyclobutyl-2-pentalenal    B) 1,1-dichloro-2-butyl-3,4,5-trimethylphenyl ether  
C) 3 different alcohols ( 1°, 2°, 3° ) all with the formula C<sub>5</sub>H<sub>12</sub>O

33. Complete the following reaction equations & name the product in each case !



- The heat of formation at std conditions  $\Delta H^\circ_f$  for each element has a value of .....
- When ice melts, the product is more ( *ordered / disordered* ) therefore  $\Delta S$  is ( *positive / negative* )
- What are the 5 factors that affect the rate of a rx \_\_\_\_\_
- A rx with the rate expression,  $\text{rate} = k [\text{Cr}^{3+}]^2 [\text{H}^+]$  is \_\_\_\_\_ order  $\text{Cr}^{3+}$
- The temperature of a substance is related to the average \_\_\_\_\_ energy of that chemical substance.
- For a 1st order reaction , the rate constant  $\rightarrow K$  has units of \_\_\_\_\_
- If a rx is 2nd order for reactant B and the  $[\text{B}]$  is quadrupled what will happen to the rate \_\_\_\_\_
- If a rx is 1/2 order for catalyst C and the  $[\text{C}]$  is quadrupled what will happen to the rate \_\_\_\_\_
- $\text{CO} + 1/2 \text{O}_2 \rightarrow \text{CO}_2$  Write the  $K_e$  expression for this gaseous rx \_\_\_\_\_
- Consider  $\text{H}_2 (\text{g}) + \text{X}_2 (\text{g}) \rightarrow 2\text{HX} (\text{g})$ . At a certain temp the following concentrations were measured  
 $[\text{H}_2 (\text{g})] = 0.50 \text{ M}$ ,  $[\text{X}_2 (\text{g})] = 1.0 \text{ M}$  &  $[\text{HX} (\text{g})] = 0.30 \text{ M}$ . What is  $K_e$  for this reaction at this temperature .....
- Consider  $\text{H}_2 (\text{g}) + \text{I}_2 (\text{g}) \rightarrow 2\text{HI} (\text{g})$ . At 695 K the  $K_e = 54.6$ . If the  $[\text{H}_2 (\text{g})] = [\text{I}_2 (\text{g})] = 1.5 \times 10^{-3} \text{ M}$  calculate the concentration of  $\text{HI} (\text{g})$  at this temperature. \_\_\_\_\_
- Calculate the  $K_{sp}$  value for magnesium fluoride if its solubility is  $1.67 \times 10^{-3} \text{ g/100 mL}$  at  $18^\circ\text{C}$  .....
- 10.0 g of sodium hydroxide are dissolved in 250 mL of water, what is the  $[\text{NaOH}]$  ? .....
- What is the  $K_a$  value for chlorous acid if the acid is 0.68 M and 13.8 % ionized at  $25^\circ\text{C}$  .....
- The  $K_w$  formula for water = ..... & has a value of ..... ;  $\text{pH} + \text{pOH} =$  .....
- a) What is the pH of a sol'n which has a hydrogen ion concentration =  $4.0 \times 10^{-8}$  \_\_\_\_\_  
b) What is the pH of 100 mL of a 0.01 M  $\text{H}_2\text{SO}_4$  solution \_\_\_\_\_  
c) What is the  $[\text{H}^+]$  in a solution with  $\text{pH} = 4.2$  \_\_\_\_\_
- Calculate the pH of a sol'n containing  $7.0 \times 10^{-2} \text{ M OH}^-$  \_\_\_\_\_
- Calculate the pOH of a sol'n containing  $2.50 \times 10^{-6} \text{ M H}^+$  \_\_\_\_\_
- Complete this eq'n  $\text{HBr} + \text{HCO}_3^- \rightarrow$  \_\_\_\_\_ + \_\_\_\_\_. The L-B acids are \_\_\_\_\_ & \_\_\_\_\_
- What does the term amphoteric mean: .....
- Would  $\text{Na}_2\text{HPO}_4$  be acidic or basic? ..... why? .....  
b) would  $\text{AlCl}_3$  be acidic or basic? ..... why? .....
- The oxidation number of oxygen in  $\text{H}_2\text{O}$  is \_\_\_\_\_ of N in  $\text{NH}_4^+$  \_\_\_\_\_ of Cl in  $\text{KClO}_4$  \_\_\_\_\_
- What is the value of  $E^\circ$  for  $\text{Pb} + 4 \text{H}^+ + 2 \text{NO}_3^- \rightarrow 2\text{H}_2\text{O} + 2 \text{NO}_2 + \text{Pb}^{2+}$  \_\_\_\_\_
- How many grams of nickel will be deposited if 1.5 F are passed thro nickel sulfate sol'n? \_\_\_\_\_
- 24 125 C are passed thro a cell containing iron(III) ions. How many grams of iron will plate out? \_\_\_\_\_
- Compounds with the carbonyl group (CO) attached to at least one hydrogen are called \_\_\_\_\_
- Compounds with the carbonyl group (CO) in between 2 carbons are called \_\_\_\_\_
- The carboxyl group  $-\text{COOH}$  on a long hydrocarbon makes a compound a \_\_\_\_\_
- When ethene is reacted with  $\text{Cl}_2$  \_\_\_\_\_ results via a \_\_\_\_\_ reaction
- Write a balanced redox equation for the rx of ethanol with dichromate to form ethanal in an acidic solution.

Text Questions (see practice problems answers from the units to get the solutions)

**Unit 1:** pg 302 #9-11, pg 308 #1-2, pg 310 #4-5, pg319#2-3, pg 326#1-2, pg 335 #5, pg 498#1, pg 361#1-2pg 364#3-4, pg 377 #4,6, pg 381 # 7,8,4

**Unit 2:** pg 437#6,7, pg 457 #1, pg 444#2-4, pg 465 #1, pg 486#1-4, pg489#5, pg 532#1, pg 537#4-5, pg 546#12-14, pg 549#17-19pg 554 #1-2, pg 556#3, pg 563#6, pg 568#7, pg 570#9, pg 574#12, pg 88#1, pg 594#5, pg 599 #1,2pg 620#3

**Unit 3:** pg 657#9, pg 662#19, pg 668 #2-3, pg 673 #6-7, pg 700#6a, pg 708#10ab, pg 735#1a,2a, pg 748#1-4, pg 749 #5-7, pg752#9-10

**Unit 4:** pg 16#1b-d, 2, pg 19 #5b-e,6, pg 21 #7, 8a-c, pg33#1-2, pg 46 #11, pg 51#1-3, pg 60#1-2, pg 72 # 2-3, pg 76 #4-6, pg 27 #1, pg 30 #4, pg 31 # 3 a-d, pg 37 #6, pg 68 #3