# FINAL REVIEW: SCH4U

1. a) Make a glossary of terms from each unit.
    b) State and explain each law or theory from each unit.
    c) Make a list of all formulas from each unit.
    d) Draw a sample diagram from each unit.
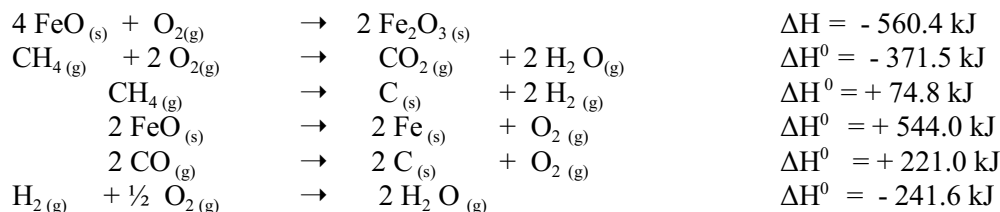   e) Try the questions that follow.

THERMOCHEMISTRY

1. When 33.45 kJ of heat is applied to an aluminium calorimeter that has a mass of 244.0 g, the temperature rises from 31.8 °C to 70.9 °C.
    a) Calculate the specific heat of aluminium.
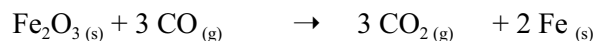   b) Calculate the molar heat capacity of aluminium.

2. For the complete combustion of octane, ΔH^0 = - 4597 kJ/mol according to the reaction

$$C_8H_{18}(g) \quad + \quad O_2(g) \quad \rightarrow \quad CO_2(g) + \quad H_2O(l)$$
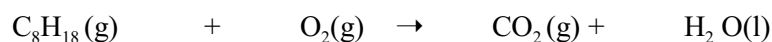
a) Balance the above reaction

b) Use the above information and the table provided to find the standard heat of formation (ΔH_f°) of octane.

3. Using the following equations:

$4 FeO_{(s)} + O_{2(g)}$	$\rightarrow \quad 2 Fe_2O_{3(s)}$	$\Delta H = $ - 560.4 kJ
$CH_{4(g)} + 2 O_{2(g)}$	$\rightarrow \quad CO_{2(g)} + 2 H_2O_{(g)}$	$\Delta H^0 = $ - 371.5 kJ
$CH_{4(g)}$	$\rightarrow \quad C_{(s)} + 2 H_{2(g)}$	$\Delta H^0 = $ + 74.8 kJ
$2 FeO_{(s)}$	$\rightarrow \quad 2 Fe_{(s)} + O_{2(g)}$	$\Delta H^0 = $ + 544.0 kJ
$2 CO_{(g)}$	$\rightarrow \quad 2 C_{(s)} + O_{2(g)}$	$\Delta H^0 = $ + 221.0 kJ
$H_{2(g)} + \frac{1}{2} O_{2(g)}$	$\rightarrow \quad 2 H_2O_{(g)}$	$\Delta H^0 = $ - 241.6 kJ

find the ΔH for the following reaction:

$$Fe_2O_{3(s)} + 3 CO_{(g)} \quad \rightarrow \quad 3 CO_{2(g)} + 2 Fe_{(s)}$$

4. a) What two conditions are necessary for a successful reaction to occur spontaneously?

    b) For the reaction:
    $$2 N_2O_{5(g)} \quad \rightarrow \quad 4 NO_{2(g)} \quad + O_{2(g)} \quad \Delta H^0 = + 126.4 kJ$$
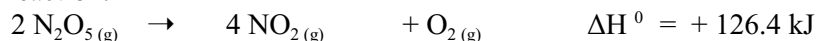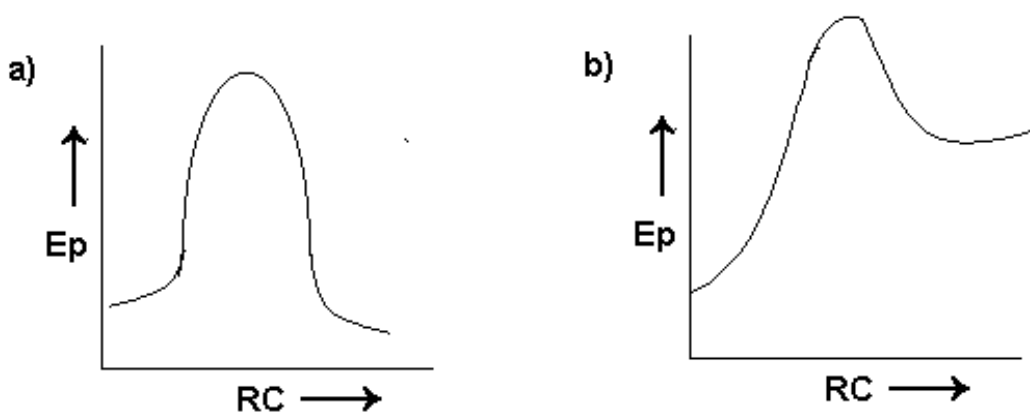
    Is the reaction favourable in terms of : (support your answers)
    (i) enthalpy
    (ii) entropy

1

5.   Consider the following potential energy diagrams:

a)

b)

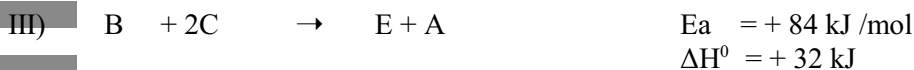Which of the above potential energy diagrams represents:
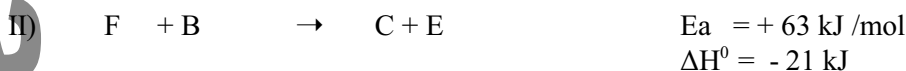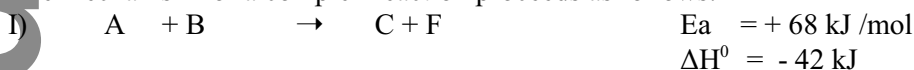   (i)   an exothermic reaction
   (ii) The fastest reaction (Assume equal scales)

RATES OF REACTION
1.   Regarding the rates of chemical reactions:
   a) What are **four** factors which affect reaction rates?
   b) Use the collision theory to explain only **two (2)** of the above in part a).

2.   The mechanism for a complex reaction proceeds as follows:

   I)   A + B   →   C + F   Ea   = + 68 kJ /mol
                                                       ΔH^0 = - 42 kJ

   II)   F   + B   →   C + E   Ea = + 63 kJ /mol
                                                       ΔH^0 = - 21 kJ

   III) B   + 2C   →   E + A   Ea   = + 84 kJ /mol
                                                       ΔH^0 = + 32 kJ

   a) Draw and fully label an accurate energy curve to represent the steps of this reaction, show your scale.
   b) What is the overall equation for this reaction (show the catalyst) ?
   c) What is the Δ H (forward) for the overall or net reaction?
   d) Which step would be the rate determining step?
   e) State the reaction intermediate (s) in this reaction.
   f) State the catalyst(s) in this reaction.
   g) Which step(s) is (are) exothermic?

3.   Given the following reaction with experimental data:
   $C_4H_{11}CF_{(aq)}$ + $OH^{-1}_{(aq)}$ ⟶ $C_4H_{11}COH_{(aq)}$ + $F^{-1}_{(aq)}$
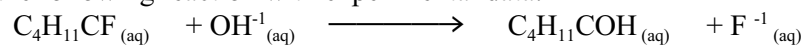
Trial	Initial [C₄H₁₁CF] (mol/L)	Initial [OH⁻] (mol/L)	Initial Rate of Formation of F⁻ (mol/L/s)
1	0.10	0.20	5.5×10^{-4}
2	0.20	0.20	1.1×10^{-3}
3	0.10	0.40	5.5×10^{-4}

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a) Determine the order of the reaction with respect to $C_4H_{11}CF$
b) Determine the order of the reaction with respect to OH^-
c) What is the overall order of the reaction ?
d) Write the rate law expression for the reaction.
e) Determine the value of the rate law constant for the reaction.
f) State the molecularity of the reaction.

CHEMICAL EQUILIBRIUM

1. Given the equation:
$$CO_{(g)} + H_{2\,(g)} \rightleftharpoons C_{(s)} + H_2O_{(g)} \qquad \Delta H^0 = -131.3 \text{ kJ}$$
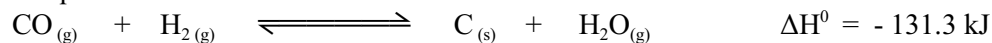
   a) Write the equilibrium law expression (K_c) for the above reaction.

   b) Determine the value of the equilibrium constant if at equilibrium.
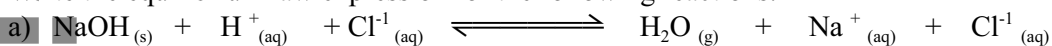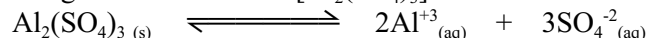 $[CO] = 3.2 \times 10^{-3} \text{ mol/L}$ $\qquad\qquad$ $[H_2] = 2.5 \times 10^{-4} \text{ mol/L}$
 $[C] = 6.35 \times 10^{2} \text{ mol/L}$ $\qquad\qquad$ $[H_2O] = 5.4 \times 10^{-4} \text{ mol/L}$

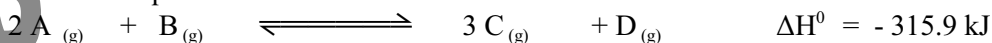2. Write the equilibrium law expression for the following reactions:
   a) $NaOH_{(s)} + H^+_{(aq)} + Cl^{-1}_{(aq)} \rightleftharpoons H_2O_{(g)} + Na^+_{(aq)} + Cl^{-1}_{(aq)}$

   b) Dissolving aluminum sulfate $[Al_2(SO_4)_3]$ solid in water.
   $$Al_2(SO_4)_{3\,(s)} \rightleftharpoons 2Al^{+3}_{(aq)} + 3SO_4^{-2}_{(aq)}$$

3. a) What is the difference between a physical and a chemical equilibrium ?
   b) State whether each of the following is a homogeneous or heterogeneous equilibrium.
   (i) $Br_2\,(g) + 5\,F_2(g) \rightleftharpoons 2BrF_5\,(g)$
   (ii) $Ca_3(PO_4)_2\,(s) \rightleftharpoons 3\,Ca^{2+}\,(aq) + 2\,PO_4^{3-}\,(aq)$
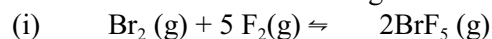
4. Given the equation:
$$2A_{(g)} + B_{(g)} \rightleftharpoons 3C_{(g)} + D_{(g)} \qquad \Delta H^0 = -315.9 \text{ kJ}$$

   a) Write the equilibrium law expression (K_c) for the above reaction.

   b) When equal volumes of A and B are combined in a 3.5 L flask, their initial concentrations were each 1.75 mol/L. Once equilibrium is reached, the equilibrium concentration of C , is $[C] = 0.65$ mol/L. Determine the K_c for this reaction.

5. Consider the following reaction:
$$N_{2\,(g)} + 3\,H_{2\,(g)} \rightleftharpoons 2\,NH_{3\,(g)} \qquad \Delta H^0 = -92.2 \text{ kJ}$$
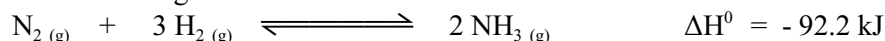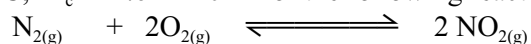
   What are the ideal conditions that would favour the greatest yield of ammonia? Justify.

6. 0.550 mol of nitrogen are combined with 0.350 mol of oxygen in a 4.00 L flask and allowed to reach equilibrium. Determine the equilibrium concentration of each substance.
$$N_{2\,(g)} + O_{2\,(g)} \rightleftharpoons 2\,NO_{(g)} \qquad K_c = 2.51 \times 10^{-7}$$
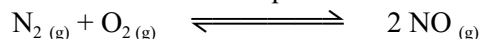
7. At 25 ^{O}C, $K_c = 1.61 \times 10^{-17}$ for the following reaction:
$$N_{2(g)} + 2O_{2(g)} \rightleftharpoons 2\,NO_{2(g)}$$
   In air, the concentrations of nitrogen and oxygen gas are:
   $[N_2] = 0.0350 \text{ ml.L}^{-1}$, $\qquad$ $[O_2] = 0.0850 \text{ ml.L}^{-1}$
   Assume these to be the initial concentrations, what is the concentration of $NO_{2(g)}$ in air?

SOLUBILITY EQUILIBRIUM

1. a) Write the balanced equation for the reaction between potassium phosphate $\{K_3PO_4\}$ and magnesium nitrate $\{Mg(NO_3)_2\}$.
    b) Write the ionic equation for the above reaction.
    c) Write the net ionic equation for the above reaction.
    d) Write the dissociation reaction for the dissolving of the possible precipitate.
    e) Write the Ksp for the above precipitate.

2. When $CaCO_3$ is dissolved in 100.0 mL of water, a saturated solution contains how many mols of Ca^{2+} ions? ($K_{sp}(CaCO_3 = 8.70 \times 10^{-9}$)

3. The solubility product constant (K_{sp}) of $Ag_2CrO_{4\,(s)}$, in water is 5.02×10^{-13} at 25 °C. What is the solubility of silver chromate (in g/L) at 298 K?

4. A 50.0 mL volume of 0.0420 mol/L $Ca(NO_3)_2$ is added to 150.0 mL of 0.00810 mo/L $(NH_4)_2SO_4$ solution. Will a precipitate form if the Ksp for the possible precipitate is 2.61×10^{-4} ?

5. Calculate the maximum fluoride ion concentration possible in an aqueous solution that is already 0.750 mol/L barium nitrate $\{Ba(NO_3)_3\}$. The Ksp for barium fluoride $\{BaF_2\}$ is 1.71×10^{-6}.

6. Milk of Magnesia is commonly used as an antacid, chemically it is a suspension of magnesium hydroxide, $Mg(OH)_2$. If the K_{sp}, of magnesium hydroxide is 1.20×10^{-11}, determine how many grams of magnesium hydroxide must be dissolved in 25 mL of water to make the antacid.

IONIC EQUILIBRIUM

1. Which of the following is the strongest acid ?
    a) H_2PO_2 b) H_2PO_3 c) H_2PO_4

2. Briefly distinguish between an Arrhenius base, a Bronsted-Lowry base, and a Lewis base. Give a suitable, yet different example of each.

3. a) Use the salt sodium acetate $NaC_2H_3O_2$ to explain hydrolysis. Include chemical equations and written explanations.

    b) Would a solution of sodium acetate be acidic, basic or neutral ?

4. A 0.0020 mol/L solution of acetic acid (CH_3CO_2H) is 5.60% ionized at 40°C. Calculate its K_a at this temperature.

5. Find the hydrogen and hydroxide ion concentrations, pH and pOH in a solution made by mixing 10.5 mL of 0.12 mol/L KOH with 17.5 mL of 0.20 mol/L HCl.

6. Hydrofluoric acid is a <u>weak</u> acid. Suppose you dissolve 39.98 g of the acid in enough water to make 5.00 L of solution. K_a for HF is 2.56×10^{-4}. Calculate the concentration of the H^+ ion in solution, and the pH of hydrofluoric acid solution.

7. Hypobromous acid, $HOBr_{(aq)}$, has a $K_a = 3.75 \times 10^{-8}$ at a given temperature. Calculate the pH of a 0.225 M solution of hypobromous acid. State clearly any assumptions you have made at arriving your answer.

8. A new drug obtained from the seeds of a strange Colombian plant was found to be a weak organic base. A solution of this weak base has a concentration of 0.0100 mol /L, and a pH of 10.8. Determine the K_b for the drug.

9. Caffeine is a weak base that is related to ammonia. For the purposes of this example, we can abbreviate its formula to CafN. It has a base ionization constant, $K_b = 4.44 \times 10^{-5}$ at 25°C. Calculate the pH of a 0.575 mol / L solution of caffeine at 25 °C.

10. The following table gives the pK_a value for three hypothetical acids, HA, HB, and HC:
11.

Acid	pK_a
HA	6.5
HB	3.3
HC	0.6

Determine which is the :
  (a) weakest acid   (b) weakest base

12. Consider the following acid-base equilibria, the formation of products is strongly favoured in this equilibria:

$$HX \quad + \quad Y^{-1} \quad \rightleftharpoons \quad HY \quad + \quad X^{-1}$$

(a) Identify the bases competing for protons.
(b) Which base is stronger?
(c) Which is the weaker acid HX or HY?
(d) Does the K_a for this system have a large or small value?
(e) How is the equilibrium affected by the addition of the soluble salt $NaY_{(aq)}$?

13. Oxalic acid is a _diprotic_ acid. 0.200 g of oxalic acid, $H_2C_2O_4$ was neutralized with 35.5 mL of $NaOH_{(aq)}$. Determine the concentration of the $NaOH_{(aq)}$.

14. Succinic acid, $C_4H_4O_4H_2$, is a _diprotic_ acid. A 50.0 mL sample of succinic acid was prepared using _solid_ succinic acid. This sample was titrated with 0.255 mol / L solution of sodium hydroxide using phenolphthalein as indicator . The following results were obtained:

Volume of succinic acid (mL)	50.0
Volume of $NaOH_{(aq)}$ (mL)	18.45
Concentration of $NaOH_{(aq)}$ (mol / L)	0.255

(a) Write a balanced chemical equation to represent the complete reaction of the diprotic succinic acid, $C_4H_4O_4H_{2\ (aq)}$ with sodium hydroxide, $NaOH_{(aq)}$, include all state symbols.

(b) Calculate the number of moles of $NaOH_{(aq)}$ used

(c) Calculate the number of moles of succinic acid reacted

(d) the mass of succinic acid in the 50.0 mL of sample titrated.

BONDING & SHAPES

1. a) What is the 'Pauli Exclusion Principle'? Be sure to include an example.
    b) What is the VSEPR theory?
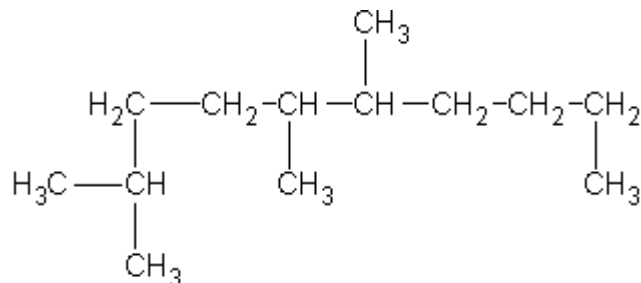   c) Use the VSEPR theory to discuss the bond angle in a molecule of water.

2. Complete the table below:

Formula	Lewis Structure	Shape	Bond Angle	Polar or Non-polar
$CHCl_3$				
BrO_3^-				
SiS_2				
ICl_5				
CO_3^{2-}				
CrI_6				
PBr_4^+				

3. a) What is the electron configuration of the following ions:
    (i) S^{2-} (ii) Fe^{+3} (iii) Br^{-1}
    b) What is the outermost electron orbital & number of electrons in the electron configuration that represents a halogen?

4. In terms of all intermolecular forces present, explain why the boiling point of water, H_2O, is more than 120^0 higher than the boiling point of hydrogen selenide, H_2Se.

5. Rationalize the difference in the boiling point methoxy methane, CH_3OCH_3, $-23.7\,^OC$ and ethanol, CH_3CH_2OH, $78.4\,^OC$.

6. Rationalize the difference in boiling points between pentane, $CH_3CH_2CH_2CH_2CH_3$, $36.2\,^OC$ and propane, $CH_3CH_2CH_3$, $-42\,^OC$.

7. Briefly explain how the valence shell electron pair repulsion theory, (VSEPR Theory), is used to predict molecular shapes.

8. Draw Lewis diagrams and predict the shape, bond angles and the polarity of the following molecules:
    Cl_2O $BeCl_2$ XeF_3^{+1} ClF_4^{-1} CO_3^{-2}

9. Phosphorus can form PCl_3 and PCl_5. Explain why nitrogen can form NCl_3 but not NCl_5.

10. Do NF_3 and BF_3 have the same shape? Explain.

ORGANIC

1. The correct IUPAC name for the structure below is: _____

$$H_2C-CH_2-CH-\overset{\overset{\displaystyle CH_3}{|}}{CH}-CH_2-CH_2-CH_2$$

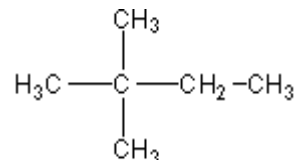with H_3C-CH and CH_3 and CH_3 branches, and CH_3 below.

2. Butanoic acid and ethanol can be used to produce_____, in the presence of concentrated sulphuric acid as a catalyst.

3. An amine is characterized by what functional group? _____

4. The correct name for this compound is_____

$$H_3C-\overset{\overset{\displaystyle }{|}}{C}=CH_2$$
$$H_2C-CH_3$$
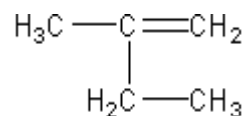
5. What is the correct name for: _____

$$H_3C-\overset{\overset{\displaystyle CH_3}{|}}{\underset{\underset{\displaystyle CH_3}{|}}{C}}-CH_2-CH_3$$

6. The compound : CH_3CHO is classified as_____?

7. When a secondary alcohol is oxidized, the product is _____.

8. The reaction of $CH_3CH=CH-CH=CH_2$ with excess bromine will form the product _____.

9. The formula for methyl ethanoate is: _____

10. Butane and fluorine gas would react by which of the following?
a. addition   c. substitution
b. combustion   d. single displacement

11. Which one of the following compounds is **not** expected to be completely soluble in water at room temperature?
a. $CH_3CH_2CH_2OH$ c. $CH_3(CH_2)_{16}COOH$
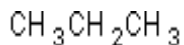b. CH_3COOH d. CH_3OH

12. Explain what is meant by the term "isomers". Illustrate your answer using the compounds with the molecular formula: C_3H_6O.

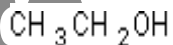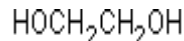13.   Select the compound with the highest boiling point at standard pressure.

a.

CH_4

b.

$CH_3CH_2CH_3$

c.

CH_3CH_2OH

d.

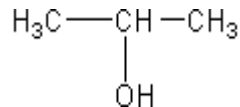$HOCH_2CH_2OH$
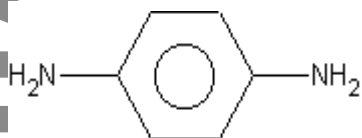
e.

$H_3C—CH—CH_3$
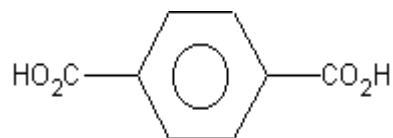 |
           OH

14.   The proper term used to describe a polymer made by combining large numbers of identical monomers is: _____

15.   Kevlar, a strong polymer used in bullet proof vests, is made by the following condensation of monomers:
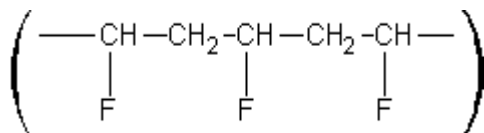
$H_2N—\langle\bigcirc\rangle—NH_2$ and $HO_2C—\langle\bigcirc\rangle—CO_2H$

The structure of the polymer Kevlar is _____.

16.   The monomer that must be used to produce the polymer given below is _____.

$$\left(—CH—CH_2—CH—CH_2—CH—\right)$$
$$\quad\;\; |\qquad\qquad |\qquad\qquad |$$
$$\quad\;\; F\qquad\qquad F\qquad\qquad F$$

17.   Nomex is a polymer used to make flame-resistant clothing for firefighters. A portion of its structure is provided below. Write a polymerization reaction showing its production from monomers. What type of reaction is this?
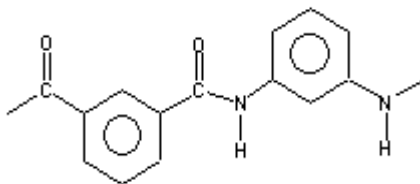
18.   Draw the structure of the polymer formed by the condensation reaction between the following substances:

$H_2N—CH_2-CH_2-CH_2-CH_2-NH_2$ + $HO_2C—CH_2-CH_2-CH_2-CO_2H$

8