UBC CHEM 154 - Sample Final Exam

CHEM 154 Students,

These questions have been assembled in order to aid your study for the final exam. This sample exam is roughly the length and scope you should expect for the actual exam. The questions have been selected to mirror the difficulty of the final exam as much as possible. Keep in mind, however, that not every topic in the course is tested here. As such you should be as familiar as possible with the complete lecture notes, worksheet problems, Sapling assignments, and suggested textbook problems in addition to the problems presented here.

We suggest you use this document to familiarize yourself with roughly what you can expect to see on exam day.

Good luck!

CHEM 154 Team

Part 1. Multiple Choice

For each numbered question below, write the letter that corresponds to the best answer in the box provided. Use CAPITAL LETTERS only. **Only the answer given in the box will be marked.** There is only one correct answer per question.

Answer: C

1. What does the decrease in the free energy of a system (ΔG_{sys}) imply about the change in entropy of the universe (ΔS_{total}) and the spontaneity of the change?
   a. ΔS_{total} is positive and the process is not spontaneous.
   b. ΔS_{total} is negative and the process is not spontaneous.
   c. ΔS_{total} is positive and the process is spontaneous.
   d. ΔS_{total} is negative and the process is spontaneous.
   e. None of the above.

Answer: D

2. What is the molecular shape of NF_3?
   a. Tetrahedral
   b. Square planar
   c. See-saw
   d. Trigonal pyramidal
   e. Octahedral

Answer: A

3. Which of the following molecules will exhibit the strongest hydrogen bonding?
   a. CH_3NH_2
   b. H_2CO
   c. PH_3
   d. CH_4
   e. HI

Answer: E

4. Which of the following statements is INCORRECT?
   a. The radius of Cl^- is greater than the radius of F^-.
   b. The radius of S^{2-} is greater than the radius of S.
   c. The radius of Rb is greater than the radius of K.
   d. The radius of Ca^+ is greater than the radius of Br^{2+}.
   e. The radius of F is greater than the radius of B.

Answer: C

5. A gas expands reversibly at a constant temperature of 25 ºC and 298 J of heat is transferred to the system. What is ΔS for the surroundings?
   a. $1\ J\ K^{-1}$
   b. $2\ J\ K^{-1}$
   c. $-1\ J\ K^{-1}$
   d. $-2\ J\ K^{-1}$
   e. $-12\ J\ K^{-1}$

Answer:
A

6. Consider a change in state from a condition P_1, V_1, T_1 to that of P_2, V_2, T_2. Which of the following statements about this change is INCORRECT?

   a. The work depends only on ΔV
   b. The temperature change is $\Delta T = T_2 - T_1$, regardless of path
   c. The heat flow varies with the path
   d. The heat lost or gained by the surroundings is equal and opposite to that lost or gained by the system
   e. All of the above are correct

Answer:
C

7. Consider the equilibrium below occurring at 298K with $K = 0.00466$:

$$N_2O_4\,(g) \rightleftharpoons 2NO_2\,(g)$$

Both gases are in a sealed vessel. At some point after addition the concentrations are measured to be $[N_2O_4] = 0.85$ M and $[NO_2] = 0.15$ M. Choose the correct statement.

   a. When the measurement is made the reaction is in equilibrium.
   b. When the measurement is made the reaction is spontaneous in the forward direction.
   c. When the measurement is made the reaction is spontaneous in the reverse direction.
   d. This reaction can never ben spontaneous because ΔG will always be positive.
   e. When the measurement is made $\Delta G = 0$ kJ mol^{-1}

Answer:
C

8. Which of the following is true about nitrogen?
   a. Nitrogen often acquires a +3 oxidation state in compounds
   b. Nitrogen can be hypervalent
   c. Nitrogen has a higher effective nuclear charge than carbon
   d. Nitrogen is more electronegative than oxygen
   e. Nitrogen atoms have a larger atomic radii than phosphorus atoms

Answer:
B

9. Which of the following pairs of species is isoelectronic?
   a. CO_2 and NO_2
   b. CH_4 and $[NH_4]^+$
   c. OF_2 and OH_2
   d. Cl_2 and O_2
   e. $[SCN]^-$ and $[OCN]^-$

Answer:
D

10. Identify the extensive variables from the list below

I. Molar enthalpy
II. Density
III. Temperature
IV. Volume

a. I only
b. II and III
c. I, II, and III
d. IV only
e. III and IV

Answer:
B

11. Consider the following Galvanic cell at $T = 298$ K:

$$Al(s)\,|\,Al^{3+}(aq)\,||\,Ag^{+}(aq)\,|\,Ag(s)$$

$$Al(s) + 3Ag^{+}(aq) \rightarrow Al^{3+}(aq) + 3Ag(s)$$

The standard cell potential is $E^{o} = 0.86$ V. Given the reaction quotient, $Q = 1$, which of the following is correct?

a. The cell potential is equal to 0 V.
b. The cell reaction is spontaneous in the forward direction.
c. The cell reaction has $\Delta G_{rxn} > 0$.
d. The cell potential is equal to 2.58 V.
e. None of the above.

Answer:
C

12. Which of the following elementary reactions will follow second order kinetics overall?

I. $N_2O_4 \rightarrow 2NO_2$
II. $CO + NO_3 \rightarrow NO_2 + CO_2$
III. $2ClO^{-} \rightarrow ClO_2^{-} + Cl^{-}$

a. I and II
b. I and III
c. II and III
d. II only
e. I, II, and III

Answer:
B

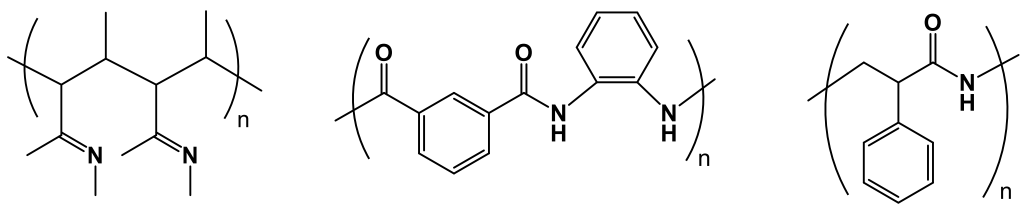
13. Based on the hanging ice-block demonstration that was done in class, what property of H_2O causes it to melt under increased pressure at constant temperature?

I. The phase change from ice to water is exothermic
II. Liquid water is more dense than ice
III. Water has multiple solid phases

a. I only
b. II only
c. III only
d. II and III
e. All of the above.

Answer:
A

14. Which of the following polymers can be synthesized by an addition polymerization?

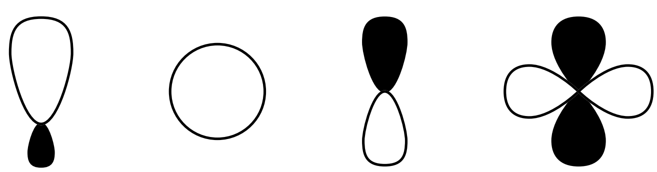


I II III

a. I only
b. II only
c. III only
d. I and II
e. II and III

Answer:
D

15. What is the general shape of the subshell containing the valence electrons in Ti^{2+}?

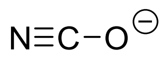
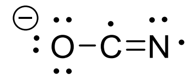
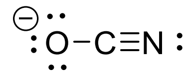
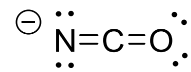


A B C D

a. A
b. B
c. C
d. D
e. None of the above.

Answer:
C

16. Which of the following is the best Lewis structure for $[OCN]^-$?

I | II | III | IV

a. I
b. II
c. III
d. IV
e. None are valid Lewis structures.

Answer:
C

17. Gases behave most ideally at:
a. Low pressure and low temperature.
b. High pressure and high temperature.
c. Low pressure and high temperature.
d. High pressure and low temperature.
e. None of the above.

Answer:
E

18. The K_{sp} of $Ca_3(PO_4)_2$ is 2.0×10^{-33}. Determine its molar solubility in 0.10 M $(NH_4)_3PO_4$.
a. 2.8×10^{-11} M
b. 1.3×10^{-11} M
c. 6.7×10^{-33} M
d. 9.2×10^{-33} M
e. 1.9×10^{-11} M

Answer:
C

19. Calculate the initial energy level of a He^+ electron that relaxes to the ground state and releases light with a wavelength of 24.3 nm.
a. n = 2
b. n = 3
c. n = 4
d. n = 5
e. n = 6

Answer:
A

20. A 400 mL container contains an ideal gas at 4.50 atm pressure. This container is connected to 300 mL container that holds a second ideal gas at 2.00 atm pressure. When the valve connecting the two containers is opened, what will the final pressure be in the two containers? Assume constant temperature.
a. 3.4 atm
b. 4.8 atm
c. 6.5 atm
d. 7.2 atm
e. 9.1 atm

Part 2. Short answer. *Full solutions not required for this section. Only your final answer will be graded for correctness.*

1. Complete each of the following sentences or phrases using correct chemical terminology. Elemental symbols may be used, where appropriate.

   a) A __**covalent**__ bond involves the sharing of two electrons between two different atoms.

   b) The energy change in the reaction below describes the ___**electron affinity**__ of bromine.

   $$Br\ (g)\ +\ e^- \rightarrow Br^-\ (g)$$

   c) The energy change in the reaction below describes the __**ionization energy**___ of bromine.

   $$Br\ (g) \rightarrow Br^+\ (g) + e^-$$

   d) The elements in group 2 all have the same number of __**valence**___ electrons.

   e) Diamond and graphite are two _**allotropes**_ of the element carbon.

   f) The molecular shape of water is ___**bent**_____ and the bond angle is ___**109.5°**__.

   g) The strongest intermolecular force you would expect to find in a sample of PF_3 is _**dipole-dipole interactions**_.

   h) Heat at constant volume is equal to __**internal energy**___, while heat at constant pressure is equal to ___**enthalpy**_________.

2. Complete the following table of information as necessary. Note that the elements are NOT necessarily neutral.

Element or Ion:	Ru	**Cl^-**
Mass number:	106	35
Number of neutrons:	**62**	**18**
Number of protons:	**44**	17
Number of electrons:	**44**	**18**
Charge:	**0**	–1

3. In each of the following groups of substances, circle the single answer that has the listed property:

a) The most valance electrons	Al	**C**	B
b) The smallest atomic radius	Br	S	**Cl**
c) The greatest electron affinity	**F**	O	Ne
d) The highest lattice energy	NaCl	KCl	**CaS**
e) The highest ionization energy	**Ne^+**	Ne	Ne^-
f) The highest boiling point	CH_4	SiH_4	**GeH_4**
g) The largest effective nuclear charge	**P**	Al	Si
h) Is a state function	w	q	**ΔU**

4. Complete the following table by providing the appropriate elemental symbol and the ground state electron configuration.

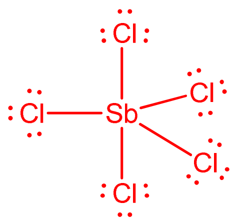
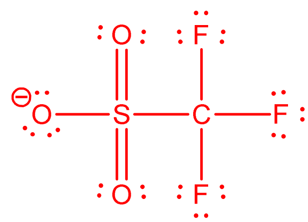
Description	Element	Electronic Configuration
The element with $Z = 7$	**N**	**$1s^2 2s^2 2p^3$**
The fourth period atom with 4 *d*-electrons	**Cr**	**[Ar] $4s^2 3d^4$**

5. Complete the following table by providing the appropriate elemental/ionic symbol and the orbital diagram.

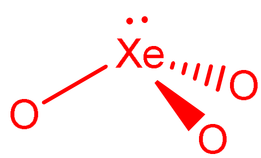
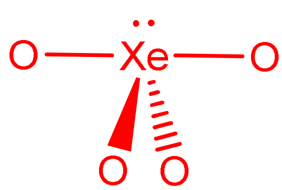
Description	Element/Ion	Orbital Diagram
The fourth period atom involved in rusting of steel	**Fe**	**[Ar]** $\underset{4s}{\underline{\uparrow\downarrow}}$ $\underbrace{\underline{\uparrow\downarrow}\ \underline{\uparrow}\ \underline{\uparrow}\ \underline{\uparrow}\ \underline{\uparrow}}_{3d}$
The ion of the above element that results when two electron are removed	**Fe^{2+}**	**[Ar]** $\underbrace{\underline{\uparrow\downarrow}\ \underline{\uparrow}\ \underline{\uparrow}\ \underline{\uparrow}\ \underline{\uparrow}}_{3d}$

6.

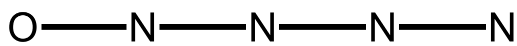
a. Draw the <u>best</u> Lewis structure for each of the following species. Draw only one structure where resonance is possible. Write any non-zero formal charges on the appropriate atoms, show all lone pairs of electrons as pairs of dots and all bond pairs as lines.

$SbCl_5$	$[SO_3CF_3]^-$
	

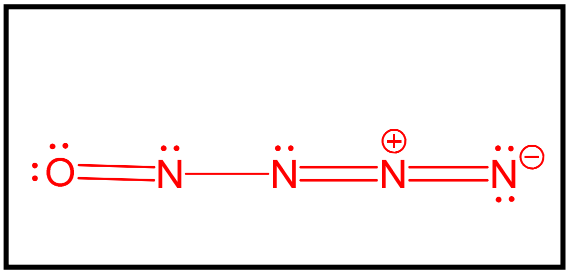
b. Complete the following table by drawing the perspective diagram and specifying the molecular shape for each molecule. In the last column clearly write “YES” if the molecule is polar, or “NO” if the molecule is not polar.

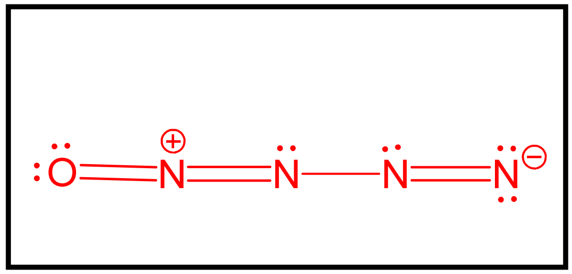
Formula	Perspective Diagram	Molecular Shape	Polar?
XeO_3		Trigonal pyramidal	Yes
$[XeO_4]^{2-}$		See-saw	Yes

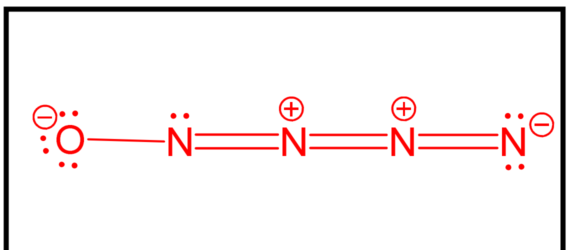
7. Draw four valid Lewis structures for nitrosylazide, N_4O, one in each box below. Acceptable structures will have only non-zero formal charges of **+1** or **–1**. Show all lone pairs of electrons as pairs of dots and all bonds as lines. Write any non-zero formal charges on the appropriate atoms. Blank space below part (b) may be used for rough work and will not be marked. The atom connectivity for nitrosylazide is given below:

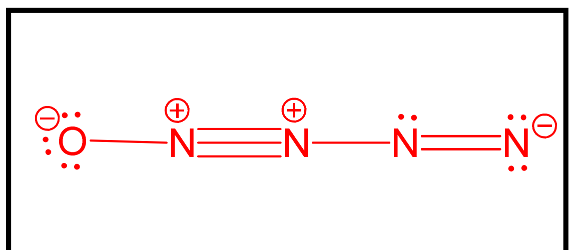


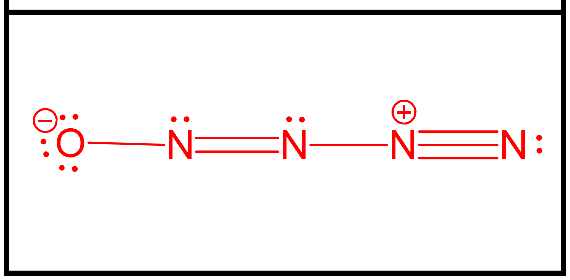
There are six possible valid Lewis structures. Any four will be considered correct.

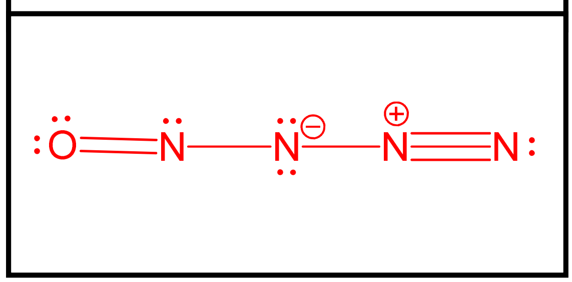




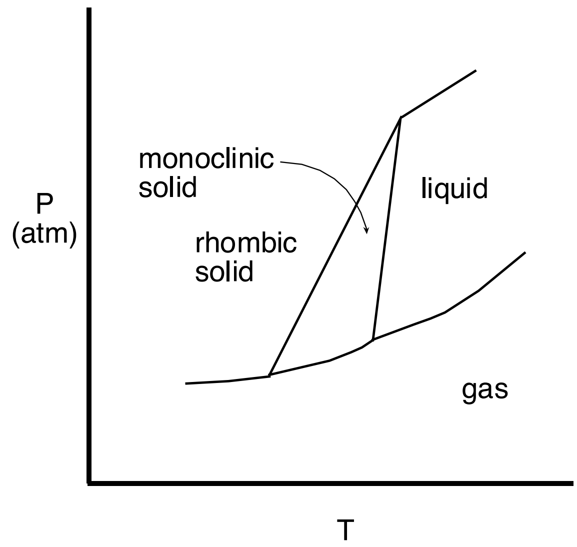








8. Consider the phase diagram for sulphur, below. Circle the correct response to each question, or fill in the missing term, where appropriate.



a. How many triple points does sulphur have?

1 2 **3** 4

b. Which phase is more dense, rhombic solid or monoclinic solid?

Rhombic Monoclinc

c. Which term best describes the monoclinic solid to rhombic solid phase transition?

Exothermic Endothermic Fusion Vaporization

d. The point on a phase diagram at which the liquid and gases phases become indistinguishable is called the ____**critical point**_____.

Part 3. Calculation and explanation questions. *Full solutions required.*

1. Consider the problems below with respect to single electron species.

   a. Calculate the energy of the transition between the ground state and first excited state of a hydrogen atom in J.

$$\Delta E = -2.18 \times 10^{-18}\text{ J } Z^2\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$\Delta E_{n=1\rightarrow n=2} = -2.18 \times 10^{-18}\text{ J } (1)^2\left(\frac{1}{2^2} - \frac{1}{1^2}\right)$$

$$\Delta E_{1\rightarrow 2} = 1.635 \times 10^{-18}\text{ J}$$

   b. A one-electron species **X** in the ground state absorbs light of 5.79 nm, resulting in an $n = 8$ excited state. What is the one-electron species?

$$E_{light} = \frac{hc}{\lambda} = \Delta E_{n=1\rightarrow n=8}$$

$$E_{light} = \frac{(6.626 \times 10^{-34}\ Js)(3 \times 10^8\ m/s)}{(5.79 \times 10^{-9}\text{ m})} = 3.43 \times 10^{-17}\text{ J}$$

$$3.43 \times 10^{-17}\text{ J} = -2.18 \times 10^{-18}\text{ J } Z^2\left(\frac{1}{8^2} - \frac{1}{1^2}\right)$$

$$Z = 4$$

One electron species with $Z = 4$ is Be^{3+}

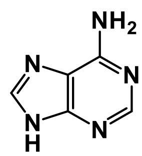
   c. When the one-electron species **X** decays from the $n = 8$ excited state to states with other values of n, light of multiple wavelengths is emitted. One of these transitions corresponds to exactly to the energy required to excite an electron in the hydrogen atom from the ground to first excited state. Determine the value of n to which the $n = 8$ excited state decays to give this energy.

$$E_{emission} = -E_{absorption}$$

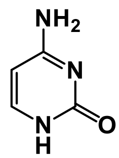
$$-2.18 \times 10^{18}\text{ J } (4)^2\left(\frac{1}{n^2} - \frac{1}{8^2}\right) = -\left(-2.18 \times 10^{18}\text{ J } (1)^2\left(\frac{1}{2^2} - \frac{1}{1^2}\right)\right)$$

$$n = 4$$

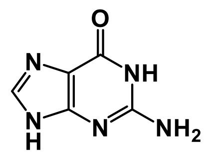
2. DNA is a double helix made-up of a mixture of four bases (guanine, cytosine, thymine, and adenine) held together by intermolecular forces. Using diagrams that include all four molecular structures below, explain why the G–C interaction is stronger than the T–A interaction.



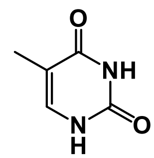
Adenine



Guanine

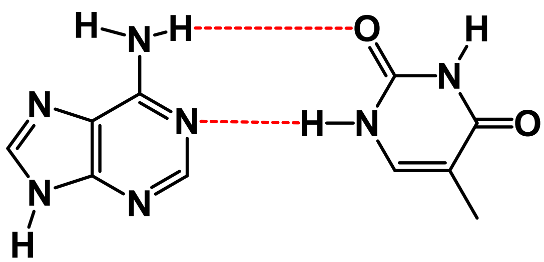


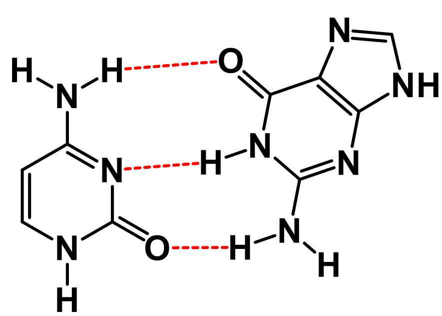
Cytosine



Thymine

Hydrogen bonding between adenine and thymine results in two hydrogen bonds (red dots shown below). Guanine and cytosine bond more strongly to each other, forming three hydrogen bonds (see below). Hydrogen bonding between adenine and guanine or adenine and cytosine are not strong because the number of hydrogen bonds possible is not maximized.





3. The equation for the formation of Fe_2O_3 (rust) may be written as

$$4Fe(s) + 3O_2(g) \rightleftharpoons 2Fe_2O_3(s)$$

Using the following data, calculate the equilibrium constant for this reaction at 298K. Write your final answer within the box, in the blank provided, as an exponent of *e*.

Compound	$\boldsymbol{\Delta H^\circ_f}$ **(kJ mol^{-1})**	$\boldsymbol{S^\circ}$ **(J K^{-1} mol^{-1})**
Fe_2O_3 (s)	–826	90
Fe (s)	0	27
O_2 (g)	0	205

To calculate *K* for this reaction, we will use

$$\Delta G^\circ = -RT \ln K$$

We must first calculate ΔG° from

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$

$$\Delta H^\circ = \sum n\Delta H^\circ\,(\text{products}) - \sum n\Delta H^\circ(\text{reactants})$$
$$= 2(-826\ \text{kJ mol}^{-1}) - 0 - 0$$
$$= -1652\ \text{kJ mol}^{-1} = -1.652 \times 10^6 \text{J mol}^{-1}$$

$$\Delta S^\circ = \sum nS^\circ\,(\text{products}) - \sum nS^\circ(\text{reactants})$$
$$= 2(90\ \text{J K}^{-1}\ \text{mol}^{-1}) - 3(205\ \text{J K}^{-1}\ \text{mol}^{-1}) - 4(27\ \text{J K}^{-1}\ \text{mol}^{-1})$$
$$= -543\ \text{J K}^{-1}\ \text{mol}^{-1}$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$$
$$\Delta G^\circ = -1.652 \times 10^6\ \text{J mol}^{-1} - (298\ \text{K})(-543\ \text{J K}^{-1}\ \text{mol}^{-1}) = -1.490 \times 10^6 \text{J mol}^{-1}$$

$$\ln K = -\frac{\Delta G^\circ}{RT} = -\frac{1.490 \times 10^6\ \text{J mol}^{-1}}{(8.3145\ \text{J K}^{-1}\ \text{mol}^{-1})(298\ \text{K})} = 601$$
$$K = e^{601}$$

$$\boxed{K = e^{\underline{601}}}$$

4. Consider the combustion of methanol:

$$2\ CH_3OH(l) + 3\ O_2(g) \rightarrow 2\ CO_2(g) + 4\ H_2O(g) \qquad \Delta H^\circ_{rxn} = -1276.8\ \text{kJ}$$

Compound	**$S°$ (J K^{-1} mol^{-1})**
CH_3OH (l)	126.3
O_2 (g)	205.1
CO_2 (g)	213.6
H_2O (g)	188.7

a. Calculate the free energy (ΔG°, in kJ) for the above reaction at 298 K.

$$\Delta S^\circ = \sum nS^\circ(\text{products}) - \sum nS^\circ(\text{reactants})$$

$$= [2(213.6\ \text{J K}^{-1}) + 4(188.7\ \ \text{J K}^{-1})] - [2(126.3\ \text{J K}^{-1}) + 3(205.1\ \ \text{J K}^{-1})]$$

$$= 314.1\ \text{J K}^{-1}$$

$$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ = -1276.8\ \text{kJ} - (298\ \text{K})(314.1\ \ \text{J K}^{-1})\left(\frac{1\ \text{kJ}}{1000\ \text{J}}\right)$$

$$\Delta G^\circ = -1370.4\ \text{kJ}$$

b. Calculate the internal energy (ΔU, in kJ) for this reaction at 298 K and 1 atm.

$$\Delta U = q + w$$

Heat at constant pressure is enthalpy

$$q = \Delta H^\circ = -1276.1\ \text{kJ}$$

$$w = -P\Delta V = -RT\Delta n = (-8.314\ \text{JK}^{-1}\text{mol}^{-1})(298\ \text{K})(3\ \text{mol})\left(\frac{1\ \text{kJ}}{1000\ \text{J}}\right) = -7.4\ \text{kJ}$$

$$\Delta U = -1276.1\ \text{kJ} + (-7.4\ \text{kJ}) = -1284.2\ \text{kJ}$$

5. Tungsten hexacarbonyl, $W(CO)_6$, is a crystalline solid commonly used as a tungsten source for depositing thin layers (nm thickness) onto microelectronic circuit boards due to its high volatility. Given the following information, determine the standard enthalpy of formation (ΔH°_f in kJ mol^{-1}) for $W(CO)_6(s)$.

Compound	**ΔH°_f (kJ mol^{-1})**
WO_3	–842.9
CO_2	–393.5

$W(CO)_6(s) + \frac{9}{2} O_2(g) \rightarrow WO_3(s) + 6\ CO_2(g)$ $\quad\Delta H^\circ_{rxn} = -2242.7$ kJ mol^{-1}

$CO(g) + \frac{1}{2} O_2(g) \rightarrow CO_2(g)$ $\quad\Delta H^\circ_{rxn} = -282.8$ kJ mol^{-1}

$W(s) + \frac{3}{2} O_2(g) \rightarrow WO_3(s)$ $\quad\Delta H^\circ_f = -842.9$ kJ mol^{-1}

$WO_3(s) + 6\ CO_2(g) \rightarrow W(CO)_6(s) + \frac{9}{2} O_2(g)$ $\quad\Delta H^\circ_{rxn} = 2242.7$ kJ mol^{-1}

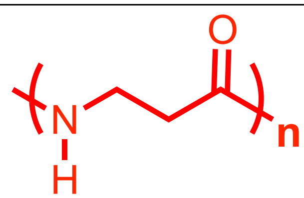
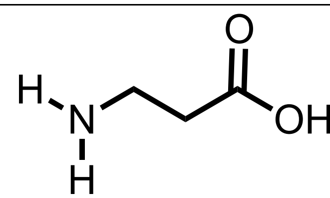
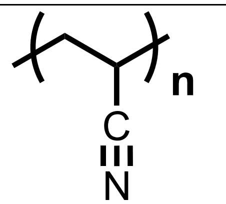
$6 \times [C(s) + O_2(g) \rightarrow CO_2(g)]$ $\quad\Delta H^\circ_{rxn} = -2361.0$ kJ mol^{-1}

$W(s) + 6\ C(s) + 3\ O_2(g) \rightarrow W(CO)_6(s)$

$\Delta H^\circ_f = -842.9$ kJ mol^{-1} $+ 2242.7$ kJ mol^{-1} $- 2361.0$ kJ mol^{-1}

$\Delta H^\circ_f = -961.2$ kJ mol^{-1}

6. Fill-in each of the blanks in the table below by drawing the corresponding monomer(s) or polymer. Lone pairs and formal charges do NOT need to be shown in the structures. You may use the shorthand notation in which a carbon atom is at the beginning or at the end of a line segment, and each carbon atom is bonded to as many hydrogen atoms necessary in order to obtain a zero formal charge.

Polymer	**Monomer**
	
	

7. The reaction of methane (CH_4) and chlorine (Cl_2) produces a mixture of products called chloromethanes. One of these is monochloromethane, CH_3Cl, used to make silicones:

$$CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$$

Calculate the heat (in kJ) released when one mol of methane and chlorine gas react to form monochloromethane and HCl, given the data below.

	C-H	**Cl-H**	**Cl-Cl**	**C-Cl**
Bond energy (kJ/mol)	414	413	243	339

$$\Delta H°_{rxn} = \sum BE(\text{reactants}) - \sum BE(\text{products})$$

$$= 1\text{mol}(C-H) + 1\text{mol}(Cl-Cl) - [1\text{mol}(C-Cl) + 1\text{mol}(Cl-H)]$$

$$= 1\text{mol}(414\text{ kJ mol}^{-1}) + 1\text{mol}(243\text{ kJ mol}^{-1}) - [1\text{mol}(339\text{ kJ mol}^{-1}) + 1\text{mol}(413\text{ kJ mol}^{-1})]$$

$$= -95\text{ kJ}$$

8. Food additives are frequently added to packaged foods to ensure a long shelf life. Thus, it is important for these molecules to decompose very slowly. Consider the following kinetic data collected at 298 K for the decomposition of food preservative A.

Experiment	[A] (mg/g)	Rate (mg g^{-1} day^{-1})
I	0.010	6.3 x 10^{-7}
II	0.020	2.5 x 10^{-6}
III	0.100	6.3 x 10^{-5}

a. What is the rate law for the decomposition of food preservative A?

$$rate = k[A]^m$$

$$\frac{2.5 \times 10^{-6}\ \mathrm{mg\ g^{-1} day^{-1}} = k[0.020\ \mathrm{mg\ g^{-1}}]^m}{6.3 \times 10^{-7}\ \mathrm{mg\ g^{-1} day^{-1}} = k[0.010\ \mathrm{mg\ g^{-1}}]^m}$$

$$4 = 2^m$$
$$m = 2$$

$$rate = k[A]^2$$

b. Calculate the rate constant, *k*, for the decomposition of preservative A at 298K.

$$k = \frac{rate}{[A]^2} = \frac{6.3 \times 10^{-7}\ \mathrm{mg\ g^{-1} day^{-1}}}{(0.010\ \mathrm{mg\ g^{-1}})^2} = 0.0063\ \mathrm{g\ mg^{-1} day^{-1}}$$

c. Preservative A is effective as a preservative only at concentrations higher than 1.0 mg/g. If a cracker bag initially contains 25.0 mg/g of preservative A, how long (in days) will the bag preserve the freshness of the crackers?

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

$$\frac{1}{1.0\ \mathrm{mg\ g^{-1}}} - \frac{1}{25.0\ \mathrm{mg\ g^{-1}}} = (0.0063\ \mathrm{g\ mg^{-1}\ day^{-1}})t$$

$$\frac{0.96\ \mathrm{g\ mg^{-1}}}{0.0063\ \mathrm{g\ mg^{-1}\ day^{-1}}} = t$$

$$t = 152\ \mathrm{days}$$

9. For each question below, consider the following electrochemical cell used at T = 298K.

   Cell reaction stoichiometry: $Fe(s) + 2Ag^+(aq) \rightarrow Fe^{2+}(aq) + 2\ Ag(s)$

   Standard reduction potentials:

   $Fe^{2+}(aq) + 2e^- \rightarrow Fe(s)$ $\quad E^\circ = -0.440$ V
   $Ag^+(aq) + e^- \rightarrow Ag(s)$ $\quad E^\circ = +0.800$ V

   a. Calculate ΔE° of the electrochemical cell.

   $$E°_{cell} = E°_{red} - E°_{ox} = 0.800\ \text{V} - (-0.440\ \text{V}) = 1.240\ \text{V}$$

   b. Calculate ΔG°_{rxn} for the electrochemical cell.

   $$\Delta G° = -nFE°_{cell} = -(2)(96500\ \text{C mol}^{-1})(1.240\ \text{V}) = -239320\ \text{J mol}^{-1}$$

   $$= -239\ \text{kJ mol}^{-1}$$

   c. Calculate the equilibrium constant for the electrochemical cell.

   $$\Delta G° = -RT \ln K$$

   $$K = \exp - \left(\frac{-239320\ \text{J mol}^{-1}}{(8.314\ \text{J K}^{-1}\ \text{mol}^{-1})(298\ \text{K})} \right)$$

   $$K = 8.92 \times 10^{41}$$

END OF EXAM!

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