Fall 2024

CHM 2045 Exam 2 Review Solutions

1. $2C_6H_6(\ell) + 15O_2(g) \longrightarrow 12CO_2(g) + 6H_2O(g)$

$1.608\,g \cdot \dfrac{1\,mol\,C_6H_6}{78.11g} = 0.0206\,mol\ C_6H_6$
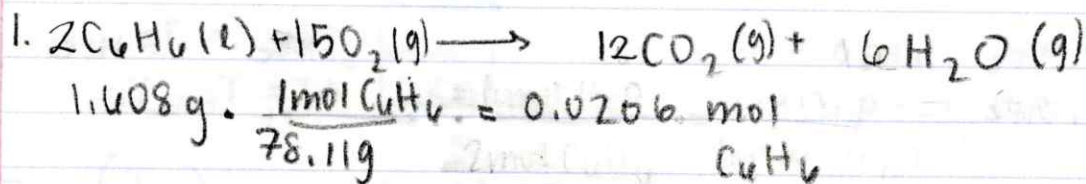
$q_{rxn} + q_{H_2O} + q_{cal} = 0$

$\qquad q_{H_2O} + q_{cal} = -q_{rxn}$

$q_{H_2O} : \ mC\Delta T$

$\qquad m = 2.45\,Kg \cdot \dfrac{1000g}{1Kg} = 2450\,g\ H_2O$

$\qquad C = 4.184\ J/g\,^\circ C$

$\qquad \Delta T = T_f - T_i = 34.852 - 25.720 = 9.132\,^\circ C$

$q_{H_2O} = 2450g \left(\dfrac{4.184J}{g^\circ C}\right)\left(9.132^\circ C\right) = 93410.31\ J$

$q_{cal} = C_{cal}\,\Delta T = \dfrac{923J}{^\circ C}\left(9.132^\circ C\right) = 8428.836\ J$

$-q_{rxn} = 93410.31 + 8428.836 = 102039.14\ J$

$q_{rxn} = -102039.14\ J \cdot \dfrac{1KJ}{1000J} = -102.04\ KJ$

$\Delta E = \Delta H + W \swarrow 0$ b/c bomb calorimeter has $\Delta V = 0$

$\Delta E = \Delta H = \dfrac{q_{rxn}}{mol\ H_2O} = \dfrac{-102.04KJ}{0.0206\,mol\ C_6H_6} = -4953.4\ KJ/mol$

$\boxed{\Delta E = -4953\ KJ/mol\ C_6H_6}$

2. $q_{Fe} + q_{H_2O} = 0$

$q_{Fe} = -q_{H_2O}$

$\boxed{T_{f\,Fe} = T_{f\,H_2O}}$
$\Delta T = T_f - T_c$

$q_{Fe} = mC_F(\Delta T)$ $= 130g(0.450\,J/g^\circ C)(\Delta T) = 58.5\,\Delta T$

$q_{H_2O} = mC_H(\Delta T)$ $= 120g(4.184\,J/g^\circ C)(\Delta T) = 502.08\,\Delta T$

$58.5\,\Delta T = -502.08\,\Delta T$

$58.5(T_f - 120) = -502.08(T_f - 22)$

$58.5\,T_f - 7020 = -502.08\,T_f + 11045.76$
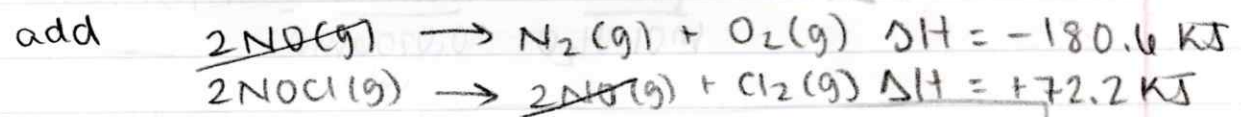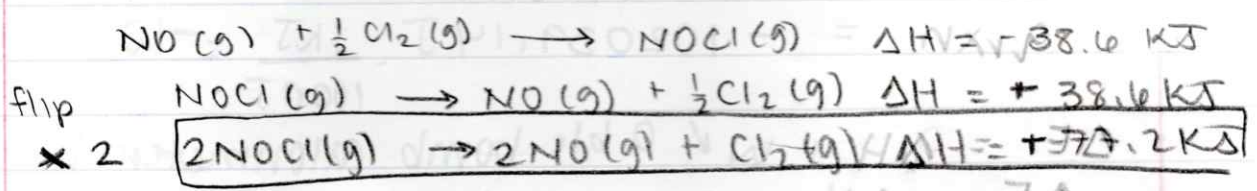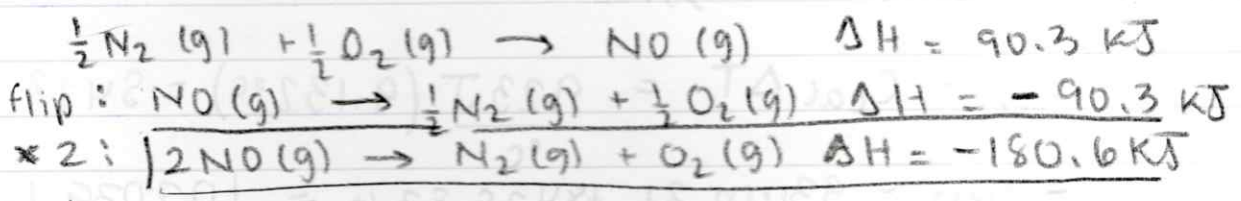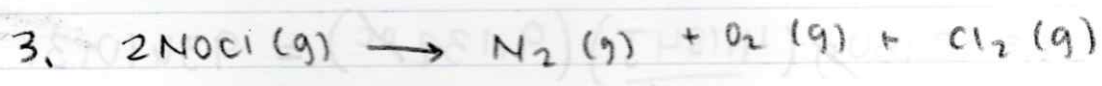
$560.58\,T_f = 18065.76$

$T_f = 32.23\,^\circ C$

3. $2\,NOCl\,(g) \longrightarrow N_2\,(g) + O_2\,(g) + Cl_2\,(g)$

$\frac{1}{2}N_2\,(g) + \frac{1}{2}O_2\,(g) \longrightarrow NO\,(g)$ $\qquad \Delta H = 90.3\,KJ$

flip: $NO\,(g) \longrightarrow \frac{1}{2}N_2\,(g) + \frac{1}{2}O_2\,(g)$ $\qquad \Delta H = -90.3\,KJ$

$\times 2$: $\underline{2\,NO\,(g) \longrightarrow N_2\,(g) + O_2\,(g) \quad \Delta H = -180.6\,KJ}$

$NO\,(g) + \frac{1}{2}Cl_2\,(g) \longrightarrow NOCl\,(g)$ $\qquad \Delta H = -38.6\,KJ$

flip $\quad NOCl\,(g) \longrightarrow NO\,(g) + \frac{1}{2}Cl_2\,(g)$ $\quad \Delta H = +38.6\,KJ$

$\times 2$ $\boxed{2\,NOCl\,(g) \longrightarrow 2\,NO\,(g) + Cl_2\,(g) \quad \Delta H = +77.2\,KJ}$

add $\quad \underline{2\,NO\,(g) \longrightarrow N_2\,(g) + O_2\,(g) \quad \Delta H = -180.6\,KJ}$

$\underline{2\,NOCl\,(g) \longrightarrow 2\,NO\,(g) + Cl_2\,(g) \quad \Delta H = +72.2\,KJ}$

$2\,NOCl\,(g) \longrightarrow N_2\,(g) + O_2\,(g) + Cl_2\,(g) \quad \Delta H = -108.4\,KJ$
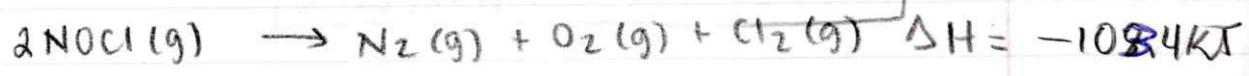
$\boxed{\Delta H_{rxn} = -103.4\,KJ}$

4. $\Delta H^\circ_{rxn} = \Sigma \Delta H^\circ_f \text{ product} - \Sigma \Delta H^\circ_f \text{ reactants}$

$= [2(\Delta H^\circ_{f\ H_2O}) + 2(\Delta H^\circ_{f\ SO_2})] - [2(\Delta H^\circ_{f\ H_2S}) + 3(\Delta H^\circ_f O_2)]$

(A)

$= [2(-241.8\ kJ/mol) + 2(-296.8\ \frac{kJ}{mol})] - [2(-20.2\frac{kJ}{mol}) + 3(0\frac{kJ}{mol}$

$= [-483.6\ kJ + -593.6\ kJ] - [-40.4\ kJ + 0]$

$= -1077.2\ kJ + 40.4\ kJ$

$\Delta H^\circ_{rxn} = -1036.8\ kJ/mol$

5. a) T: $\Delta E = q + w$

   b) F: $+\Delta T_{surrounding} = -\Delta T_{system} =$ exothermic

(A)

   c) F: $W = -P\Delta V$

   d) F: $\Delta V = 0$ for BOMB calorimeter

6. $2CH_4(l) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(g)$

   $W = -P\Delta V$

(D)

   $= -1\ atm(3-2) = -1\ L\cdot atm$

   $-1\ L\cdot atm \cdot \frac{101.3\ J}{1\ L\cdot atm} \quad \boxed{= -101.3\ J}$

7. l from $0 \longrightarrow n-1$

   m_l from $-l$ to l

(C)

   m_s either $+\frac{1}{2}$ or $-\frac{1}{2}$

8. $q = m_{H_2O} C_{H_2O} \Delta T = 155g(4.184\frac{J}{g^\circ c})(60^\circ c)$

   $q = 38911.2\ J$

(B)

$E = \frac{hc}{\lambda} = \frac{6.626\times10^{-34}\ J\cdot s\ (3\times10^8\ m/s)}{0.22m} = 9.035\times10^{-25}\ \frac{J}{photon}$

$38911.2\ J \cdot \frac{1\ photon}{9.035\times10^{-25}\ J} = \boxed{4.307\times10^{28}\ photons}$

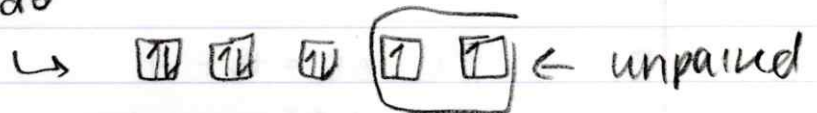(D) 9. orbital = 1 box
f shell = 7 orbitals

(C) 10. Cu is exception [Ar] $4s^1 3d^{10}$

11. paramagnetic : unpaired elections

(B) Kr = [Ar] $4s^2 3d^{10} 4p^6$ all full
~~4~~ Ni = [Ar] $4s^2 3d8$

↳ ⇅ ⇅ ⇅ |↑ ↑| ← unpaired

Mg = [Ne] $4s^2$
Zn = [Ar] $4s^2 3d^{10}$

12. isoelectronic : same e⁻ configuration

a. V = [Ar]$4s^2 3d3$ V^{3+} = [Ar] $3d^2$
Ca = [Ar] $4s^2$ ↰ ≠

b. S = [Ne] $3s^2 3p^4$ S^{2-} = [Ne] $3s^2 3p^6$ = [Ar]
(B) Ca = [Ar] $4s^2$ Ca^{2+} = [Ar] ↰ = ✓

c. Zn = [Ar] $4s^2 3d^{10}$ Zn^{2+} = [Ar] $3d^{10}$
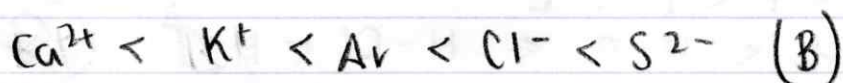Ni = [Ar] $4s^2 3d8$ ↰ ↗ ≠

d. Ne = [He] $2s^2 2p^6$ ↰ ↰ ≠
Ar = [Ne] $3s^2 3p^6$

13. size inc L → R & down table b/c Zeff
cations smaller than neutral atoms b/c same
proton & less election

13 cont'd

anions

Ca^{2+} : [Ar]
K^+ : [Ar]
S^{2-} : [Ar]
Cl^- : [Ar]
Ar
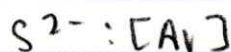
all have same e^- # so size base on
protons
(less protons, less Z_{eff}, (less pull to nucleus)
bigger size)

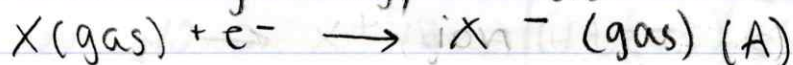$Ca^{2+} < K^+ < Ar < Cl^- < S^{2-}$ (B)

14. IE: energy need to remove 1 electron
makes huge jump when take from core shell
Ca^2 2 valence electrons
big jump when removing 3rd electron (A)

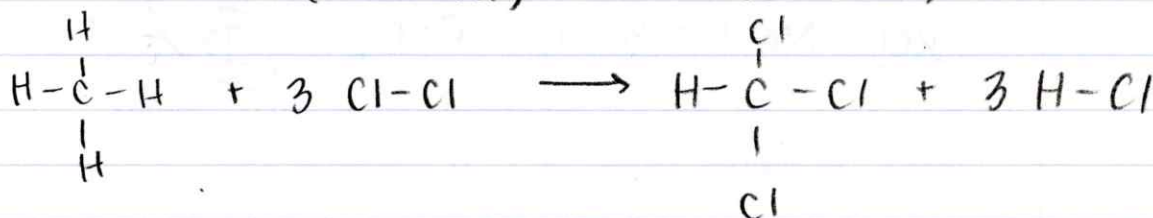15. electron affinity: energy released to add electron
$X(gas) + e^- \longrightarrow X^- (gas)$ (A)

b) solid Na need be gas
c) ionization energy (IE)
d) make no sense should be S^+ not S^- & then
it would be IE

16. $\Delta H_{rxn} = \Sigma$ bond broken $- \Sigma$ bond form
(reactant)   (product)

Final Answer:
4262kJ/mol

$$H-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}-H \quad + \quad 3 \; Cl-Cl \quad \longrightarrow \quad H-\overset{\displaystyle Cl}{\underset{\displaystyle Cl}{C}}-Cl \quad + \quad 3 \; H-Cl$$

$\Delta H_{rxn} = [4(C+H) + 3(Cl-Cl)] - [3(C-Cl) + C-H + 3(H-Cl)]$
$= [4(413kJ/mol) + 3(243kJ/mol)] - [3(-339kJ/mol) + 413kJ/mol + 3(-4...$

17. Single bond longest
    triple shortest   (A)

18. H is smallest ion
    size ↑ as you go down column, bigger size, longer
    bond
        H < F < Cl < I
    H–H < H–F < H–Cl < H–I   (C)

19. lattice energy base on __Columb Law__ $\infty \dfrac{|\text{cation}|\cdot|\text{anion}|}{r^2 \text{ (distance)}}$

    charge product more important than
    size

    charge
    $CaCl_2$ |(+2)(-1)| = 2 ← $CaCl_2$ vs $BaCl_2$
    $NaCl$ |(+1)(-1)| = 1   base on size
    KCl |1| |-1| = 1   smaller ion, more lattice energy
    $BaCl_2$ |+2| |-1| = 2 $BaCl_2$ < $CaCl_2$

                                    NaCl vs KCl
                                    KCl < NaCl
                                    bigger
                                    less LE

    $KCl < NaCl < BaCl_2 < CaCl_2$ (D)