Name: _____ date: _____ period: _____

ch. 5 (+ ch. 8.9 & 11.4). 19 thermodynamics test 75 points (+ 10 sec) ap chemistry

Academic Honesty: The answers on this test are my own and I am using only the allowed set of notes as described in the syllabus. I have not discussed the test questions with anyone before or during the test nor have I seen the test questions prior to the exam. If you violate any of the preceding items or do not sign, your semester grade is a F.

Signature: _____

In problems involving any calculation, show your work in an organized manner, include (i) any relevant equation (or formula), (ii) conversion factor(s), (iii) put the proper units in your calculations and answer, and (iv) proper number of significant figures in your answer.

1. The reaction: 3.0 g $C_2H_{6(g)}$ + 10.0g $O_{2(g)}$ → $CO_{2(g)}$ + $H_2O_{(g)}$ was used to heat 825 g of water at 20.0 °C; what is the maximum temperature of the water ? [18 → 20 points]

i) $2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$

3 g 10 g

ii) $3\text{ g}\ \frac{1\text{ mol } C_2H_6}{30\text{ g } C_2H_6}\ \frac{7\text{ mol } O_2}{2\text{ mol } C_2H_6}\ \frac{32\text{ g } O_2}{1\text{ mol } O_2} = 11.2\text{ g } O_2$ needed

∴ O_2 is limiting

iii) $\Delta H = [4\Delta H_f(CO_2) + 6\Delta H_f(H_2O)] - [2\Delta H_f C_2H_6 + 7\Delta H_f O_2]$

$= [4(-393.5) + 6(-241.8)] - 2(-84.7)$

$= -1574 - 1451 + 169$

$= -2856\text{ kJ}$

5 pts

iii) $q = -2856\text{ kJ}\left(\frac{\text{mol } O_2}{7\text{ mol } O_2}\ \frac{10\text{ g } O_2}{32\text{ g } O_2}\right) = -12.75\text{ kJ}$

iv) $q = -mc\Delta T$

$-12.75\text{ kJ}\ \frac{10^3\text{ J}}{\text{kJ}} = -825\text{ g}\left(\frac{4.18\text{ J}}{\text{g}\cdot^\circ\text{C}}\right)(T_f - 20.^\circ\text{C})$

$-12.75\cdot10^3 = -3448.5\,T_f + 68970$

$3448.5\,T_f = 81720$

$T_f = 23.7\,^\circ\text{C}$

2. Using thermodynamics, estimate the boiling point of butane. [10 points]

i) $C_4H_{10}(l) \rightarrow C_4H_{10}(g)$

ii) $\Delta G = \Delta H - T\Delta S < 0$ b/c Rx happening

$T > \frac{\Delta H}{\Delta S}$

iii) $\Delta H = \Delta H_f\, C_4H_{10}(g) - \Delta H_f\, C_4H_{10}(l)$

2 pts @ $= -124.7 - -147.6 = +22.9\ kJ$

iv) $\Delta S = S_f\, C_4H_{10}(g) - S_f\, C_4H_{10}(l)$

$= 310 - 231 = +79\ J$

v) subst $T > \frac{\Delta H}{\Delta S} = \frac{22.9 \cdot 10^3\ J}{79\ J/K} = 290\ K$ of ΔS ΔS of the

3. What is the relative magnitude of the formation of a hydration shell versus the dissociation of solid ammonium nitrate into its ions in the context of dissolving solid ammonium nitrate in water, where there was a decrease in the temperature of the water upon dissolving the solid ionic compound. Basis / rationale ? [10 points]

2 pts i) $\Delta G = \Delta H - T\Delta S < 0$ b/c solid dissolves

2 $\uparrow$

$+$ b/c $\Delta T < 0$

2 $\Delta S > \frac{\Delta H}{T} > 0$

2 ii) $\Delta S = \Delta S(\text{hydration shell formation}) + \Delta S(\text{solid} \rightarrow \text{aq})$

$-$ $+$

2 $\therefore\ |\Delta S(\text{dissociation})| > |\Delta S(\text{hydration shell formation})|$

i.e. diamond below graphite?

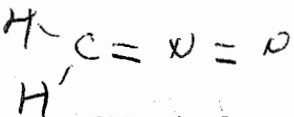
4. Based on thermodynamics, is diamond stable ? basis / rationale ? [10 points]

2 pts diamond $\rightarrow$ graphite

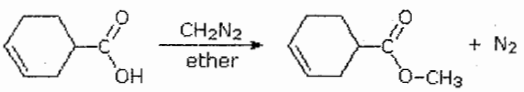
2 $\Delta G = \Delta G_f(\text{graphite}) - \Delta G_f(\text{diamond})$

3 $= (0 - 2.84)\ kJ < 0$

3 $\therefore$ unstable b/c spontaneous Rx



5. What is ΔH of the reaction: [10 points]



[source: https://chem.libretexts.org/Bookshelves/Organic_Chemistry/Supplemental_Modules_(Organic_Chemistry)/Carboxylic_Acids/Reactivity_of_Carboxylic_Acids/Reactions_of_Carboxylic_Acids]

~~Bond enthalpy of O – H: 467 kJ / mol~~

[source: https://chem.libretexts.org/Bookshelves/General_Chemistry/ChemPRIME_(Moore_et_al.)/15%3A_Thermodynamics-_Atoms_Molecules_and_Energy/15.10%3A_Bond_Enthalpies]

2 pt

6

1

1

$\Delta H = \Sigma D_{break} - \Sigma D_{form}$

$= [D(O-H) + D(C=N) + D(N=N)] - [D(O-C) + D(N_2)]$

$[D(C-H) + D(O-C) + D(N_2)]$

$= [463 + 615 + 358] - [413 + 358 + 941]$

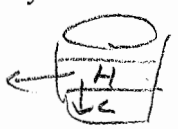
$= 1436 - 1712$

$= -276\ kJ$

6. When 40.0 mL of water at 60.0 °C is added to 40.0 mL at 25.0 °C water already in a calorimeter, the temperature rises 15.0 °C. What is the calorimeter constant? [10 points] source: https://www.chemteam.info/Thermochem/Calculate-a-Calorimeter-Constant.html

same

40°C



2pt

2

2

2

2

$-q_{lost} = q_{gain}$

$-mC(40-60)°C = mC(40-25)°C + C^x(40-25)$

$40g\left(\frac{4.18\ J}{g \cdot °C}\right)20 = 40g\left(\frac{4.18\ J}{g \cdot °C}\right)15 + C^x 15$

$3344\ J = 2508\ J + 15C^x$

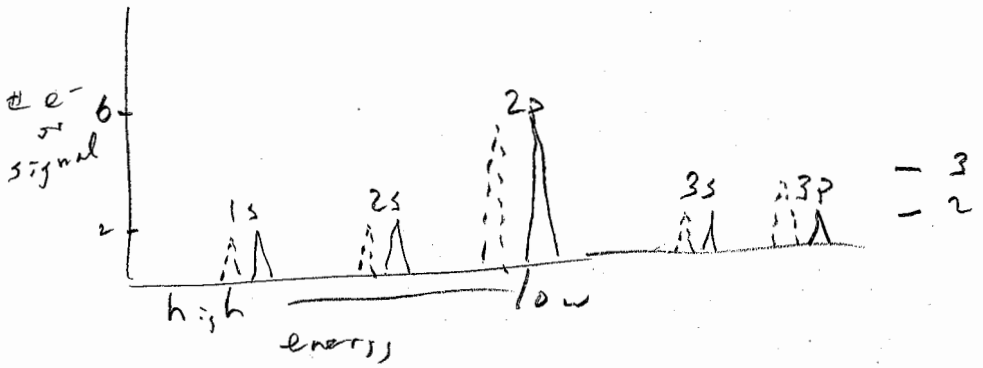
$836\ J = 15C^x$

$C^x = \frac{836\ J}{15°C} = 55.7\ \frac{J}{°C}$

7. Old topic: sketch / label the axis of the PES spectrum for silicon and phosphorus on the same PES spectrum and identify / label the source of the peaks / signals in the spectrum. [~~15~~ points]

Si: $1s^2 2s^2 2p^6 3s^2 3p^2$ — 10

P: " $3p^3$ ---



2 pts
3
3
2
- relative peak height
- relative peak location
  & label AO
- relative peak location/energy between axis
- label graph axis

} within axis