[Chapter 13 Worksheet 1]

Name: Answer Key UGA myID:

Instructions:

- Please enter your first and last name as it appears on the eLC roster (do not use a nickname).
- Your UGA myID is a combination of letters and numbers (example: mine is aw00285). **Do not use your 81x number.**
- If you do not have a printer, type your answers in the boxes then upload the worksheet template to Gradescope by **Thursday, February 11th at 11:59 p.m.** Write your work on separate sheets of paper, convert to a PDF and upload to the dropbox on eLC.
- If you have a printer download the worksheet, write your answers and show your work on the worksheet template, convert it to a PDF and upload to Gradescope by **Thursday, February 11th at 11:59 pm.**

Chapter 13-Part 1

Question 1: Which of the following pairs has the member with the greater molar entropy listed first? All systems are at 25°C. **Select all that apply.**

C, F

A. $CO(g)$, $CO_2(g)$ → more complex
B. $NaCl(s)$, $NaCl(aq)$
C. $H_2S(g)$, $H_2S(aq)$ ⇒ $S_{gaseous\ phase} > S_{liquid}$
D. $Li(s)$, $Pb(s)$
E. $H_2(g)$, $H_2O(g)$
F. $CH_3CH_2CH_2CH_2CH_3(l)$, $CH_2{=}CHCH{=}CHCH_3(l)$. → more atoms, only single bonds

Question 2: A sample of water is heated at a constant pressure of one atmosphere. Initially, the sample is ice at 260 K, and at the end the sample consists of steam at 400 K. In which of the following 5K temperature intervals would there be the greatest increase in the entropy of the sample?

D

A. from 260 K to 265 K
B. from 275 K to 280 K
C. from 360 K to 365 K
D. 370 K to 375 K ⇒ 373.15 = 100 °C, liquid → vapor phase transition
E. from 395 K to 400 K

Question 3: For chromium, Cr, the heat of fusion at its normal melting point of 1857 °C is 14.6 kJ/mol. What is the entropy change when 2.45 moles of solid Cr melts at 1857 °C?

B

A. 6.85 J/K
B. 16.8 J/K
C. 7.86 J/K
D. 19.3 J/K
E. 3.57 J/K

$\Delta q_{fusion} = 14.6\ kJ/mol$

$S = \frac{\Delta q}{T} = \frac{14.6 \times 10^3\ J}{2130\ mol \cdot K} \cdot (2.45\ mol)$

$= 16.79\ J/K$

Question 4: For which of the following changes is $\Delta S^o > 0$? Select all that apply.

A, C, E

A. $CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$
B. $4\ HCl(g) + O_2(g) \rightarrow 2\ H_2O(g) + 2\ Cl_2(g)$ ⇒ 5 mol → 4 mol, decrease
C. $2\ C_2H_6(g) + 7\ O_2(g) \rightarrow 4\ CO_2(g) + 6\ H_2O(g)$ ⇒ 9 mol of gas → 10 mol gas
D. $2\ NO(g) + 2\ H_2(g) \rightarrow N_2(g) + 2\ H_2O(l)$
E. 4 mol CH_4 (9.94 L, 215 K) → 4 mol CH_4 (19.9 L, 215 K)

↓ gas

Question 5: Which of the following is always true for an endothermic process?

A

A. $q_{sys} > 0$, $\Delta S_{surr} < 0$
B. $q_{sys} < 0$, $\Delta S_{surr} > 0$
C. $q_{sys} < 0$, $\Delta S_{surr} < 0$
D. $q_{sys} > 0$, $\Delta S_{surr} > 0$
E. None of these

Question 6:

Given: $H_2O(l) \rightarrow H_2O(g)$ $\Delta H^\circ = 40.7$ kJ at 373K

What is the entropy change in the system (ΔS) when one mole of water vaporizes at 100 °C and a pressure of one atmosphere?

C

A. 407 J/K
B. –407 J/K
C. 109 J/K
D. –109 J/K
E. None of these

$T = 373\ K$

$\Delta S = \frac{\Delta q}{T} = \frac{40.7 \times 10^3\ J}{373\ K \cdot mol} \times 1\ mol$

$= 109.1\ J/K$

Question 7: A certain process has $\Delta H^\circ > 0$, $\Delta S^\circ < 0$, and $\Delta G^\circ > 0$. The values of ΔH° and ΔS° do not depend on the temperature. Which of the following is a correct conclusion about this process?

A

A. It is non-spontaneous at all T.
B. It is spontaneous at high T.
C. It is spontaneous at low T.
D. It is spontaneous at all T.
E. None of the above.

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

Question 8: Consider the reaction: FeO (s) + Fe (s) + O_2 (g) → Fe_2O_3 (s). Given the following table of thermodynamic data:

Substance	ΔH_f° (kJ/mol)	S° (J/mol • K)
FeO (s)	–271.9	60.75
Fe (s)	0	27.15
O_2 (g)	0	205.0
Fe_2O_3 (s)	–822.16	89.96

$\Delta H^\circ = \Delta H^\circ_{products} - \Delta H^\circ_{reactants}$

$\Delta H^\circ = (-822.16) - (-271.9)$

$= -550.26\ kJ/mol$

$\Delta S = (89.96) - (60.75 + 27.15 + 205)$

$= -202.94\ J/mol\ K$

determine the temperature (in °C) at which the reaction is nonspontaneous.

B

A. below 618.1
B. above 2438
C. above 756.3
D. below 2438

$\Delta G = \Delta H - T\Delta S = 0$

$-\Delta H = -T\Delta S$

$T = +\frac{\Delta H}{\Delta S} = +\frac{-550.26}{-0.20294} = 2711.44\ K$

$= 2438.3\ ^\circ C$

Question 9: A mixture of H_2 and O_2 can sit in a flask almost indefinitely at 298 K without reacting.

$2H_2$ (g) + O_2(g) ⇌ $2H_2O$(l) $\Delta H = -285.8\ kJ\ mol^{-1}$ $\Delta S = -327\ J\ K^{-1}\ mol^{-1}$

What is the best explanation for the absence of observable reaction?

A

A. A significant energy barrier hinders the start of the reaction.
B. The reaction is not spontaneous at this temperature.
C. The reaction is entropically unfavorable.
D. All three of these factors contribute.
E. None of the above answers is correct.

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

$\Delta G = -285.8\ \frac{kJ}{mol} - (298\ K)\left(0.327\ \frac{kJ}{mol \cdot K}\right)$

$= -188 < 0$

(spontaneous)

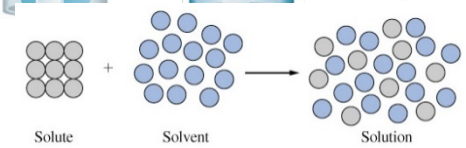
Question 10: Which of these processes would you expect to be spontaneous at all temperatures?

C only

A. $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$ $\Delta H = -200$ kJ mol^{-1}

B. 

$\Delta H = 6$ kJ mol^{-1}

C. 

$\Delta H = -5$ kJ mol^{-1}

D. None are spontaneous at all temperatures.

E. All are spontaneous irrespective of the temperature.

Question 11: For a particular reaction, the value of ΔH is -38.6 kJ/mol and ΔS is +154 J/mol K. When is this reaction spontaneous (assuming that ΔH and ΔS do not vary as the temperature changes).

D

A. At T < 251K

B. At T > 251K

C. At T < 524 K

D. This reaction is spontaneous at all temperatures

E. This reaction is not spontaneous at all temperatures

Question 12: Which of the following has the largest entropy?

B

A. 0.1 mole N_2 solid at -250 °C and 1 atm

B. 0.1 mole N_2 gas at 50 °C and 1 atm

C. 0.1 mole N_2 liquid at -200 °C and 1 atm

D. A difference in entropy cannot be detected.

Question 13: Place the following in order of increasing entropy at 298 K.

$C_2H_6(g)$, Pb(*s*), Mg(*s*), $CH_4(g)$

D

A) Mg, Pb, C_2H_6, CH_4

B) C_2H_6, CH_4, Pb, Mg

C) Pb, Mg, CH_4, C_2H_6

D) Mg, Pb, CH_4, C_2H_6

E) Pb, Mg, C_2H_6, CH_4

Question 14: For the following example, identify the following.

$H_2O(l) \rightarrow H_2O(s)$

A

A) a negative ΔH and a negative ΔS

B) a positive ΔH and a negative ΔS

C) a negative ΔH and a positive ΔS

D) a positive ΔH and a positive ΔS

E) It is not possible to determine without more information.

Question 15: For a particular reaction, the value of ΔH is -38.6 kJ/mol and ΔS is +154 J/mol K. When is this reaction spontaneous (assuming that ΔH and ΔS do not vary as the temperature changes).

D

A. At T < 251K

B. At T > 251K

C. At T < 524 K

D. This reaction is spontaneous at all temperatures

E. This reaction is not spontaneous at all temperatures

Question 16: At room temperature, ~290 K, the reaction of H_2 and O_2 to form water:

$2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(l)$ $\Delta H = -285.8\ kJ\ mol^{-1}$ $\Delta S = -327\ J\ K^{-1}\ mol^{-1}$

D

A. is spontaneous because it is exothermic.
B. is non-spontaneous because ΔS is negative.
C. is spontaneous because ΔS is negative.
D. is spontaneous because ΔG is negative.
E. is spontaneous because ΔG is positive.

$\Delta G = \Delta H - T\Delta S$
$= -285.8 - 290 \times -0.327$
$= -190\ kJ/mol$

Question 17: For the formation reaction of methane, $\Delta G = \Delta H - T\Delta S = 0$

655 Celsius

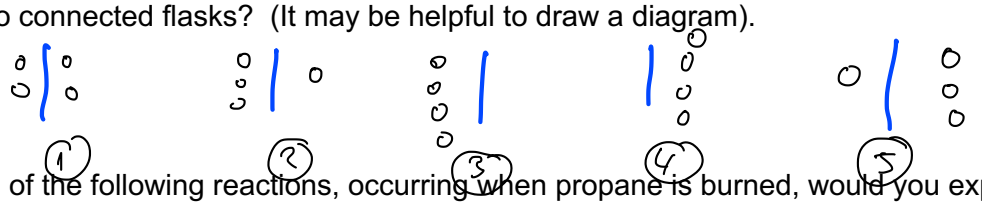
C(graphite) + 2 H_2(g) → CH_4(g)

the ΔH_f is -74.87 kJ/mol and the ΔS_{rxn} is -80.7 J/mol. At what temperature, in Celsius, does the reaction flip from being spontaneous to not spontaneous?

$\Delta H = T\Delta S$, $T = (-74.87/-0.0807) = 927.8\ K$ → indistinguishable

Question 18: How many microstates are possible in a collection of four particles that are present, with two particles each in two connected flasks? (It may be helpful to draw a diagram).

5 or 6



Question 19: Which of the following reactions, occurring when propane is burned, would you expect to be the most entropically favored (most positive change in entropy)?

B

A. $C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$ 6 mol → 7 mol

B. $C_3H_8(g) + \frac{7}{2}O_2(g) \rightarrow 3CO(g) + 4H_2O(g)$ 4.5 mol → 7 mol

C. $C_3H_8(g) + 2O_2(g) \rightarrow 3C(graph) + 4H_2O(g)$ 3 mol → 4 mol