Constants and Conversion Factors

$N_A = 6.02 \times 10^{23}$ mol^{-1}

$R = 8.31$ J/mol-K $= 8.31$ kPa-L/mol-K

1 bar $= 100$ kPa $= 750$ torr

1 kPa $= 7.50$ torr

1 J $= 1$ kPa-L

Molar Masses

C_4H_{10} - 58.

Name_____

(76)   **PART I.   MULTIPLE CHOICE (Circle the ONE correct answer)**

1. Consider the following Thermochemical equations:

$$2\ SO_2(g) + O_2(g) \rightarrow 2\ SO_3(g) \qquad \Delta H = -196\ kJ$$
$$4\ S(s) + 6\ O_2(g) \rightarrow 4\ SO_3(g) \qquad \Delta H = -1580\ kJ$$
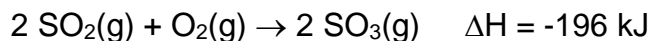
Use these equations to determine ΔH for the reaction, $S(s) + O_2(g) \rightarrow SO_2(g)$.

(A) -297 kJ   (B) -493 kJ   (C) -692 kJ   (D) +493 kJ

2. Consider the reaction: $2\ C_2H_6 + 7\ O_2 \rightarrow 4\ CO_2 + 6\ H_2O$ $\Delta H = -3122\ kJ$

Which of the following statements is/are **incorrect**?
i ΔH for forming one mole of C_2H_6 from and CO_2 and H_2O is -1561 kJ
ii ΔH for the combustion of 1.5 moles of C_2H_6 is -4163
iii   The enthalpy of formation of C_2H_6 is +1561 kJ/mol
iv   The enthalpy of formation of $O_2(g)$ is 0 kJ/mol

(A) ii & iv   (B) ii & iii   (C) ii only   (D) iii only

3. For the reaction $Fe_2O_3(s) + 3\ CO(g) \rightarrow 2\ Fe(s) + 3\ CO_2(g)$, $\Delta H = -24\ kJ$. The Enthalpy of Formations of $Fe_2O_3(s)$ and $CO_2(g)$ are -825 kJ/mol and -394 kJ/mol, respectively. Therefore, the enthalpy of formation of $CO(g)$ is

(A) -127 kJ/mol   (B) -166.5 kJ/mol   (C) -111 kJ/mol

(D) Cannot be determined without the Enthalpy of Formation of Fe(s)

4. The Fuel Value (aka Specific Enthalpy) of butane, C_4H_{10}, is 50. kJ/g. Therefore, the enthalpy change to combust **Two(2)** of butane in $O_2(g)$ to form $CO_2(g)$ and $H_2O(l)$

(A) -2900 kJ   (B) -1450 kJ   (C) +2900 kJ   (D) -5800 kJ

5. The entropy change is +237 J/K for the reaction: $2\ HgO(s) \rightarrow 2\ Hg(l) + O_2(g)$. The standard molar entropies of HgO(s) and Hg(l) are 70 J/mol-K and 86 J/mol-K. Therefore, the standard molar entropy of $O_2(g)$ is:

(A) 205 J/mol-K   (B) 0 J/mol-K   (C) 221 J/mol-K   (D) 269 J/K

6. The constant pressure molar heat capacity of $N_2(g)$ is 29.1 J/mol-K. What is the entropy change when 4 moles of N_2 are cooled from 200 °C to 50 °C at 1 bar?

(A) -23.2 J/K   (B) -11.1 J/K   (C) -161 J/K   (D) -44.4 J/K

7. A sample of 0.5 moles of $O_2(g)$ originally at 500 kPa and 5 L is expanded reversibly and isothermally to a final pressure of 100 kPa. What is ΔS for this process?

(A) +13.4 J/K   (B) +6.7 J/K   (C) -6.7 J/K   (D) +4030 J/K

8. When a gas is expanded adiabatically and reversibly, then:

   (A) $\Delta H > 0$ & $\Delta S < 0$ (B) $\Delta H < 0$ & $\Delta S = 0$ (C) $\Delta H < 0$ & $\Delta S > 0$ (D) $\Delta H > 0$ & $\Delta S = 0$

9. The normal melting point of toluene is -95 °C. The enthalpy of fusion of toluene is 6.6 kJ/mol. What is the entropy change of the **system** when one mole of liquid toluene crystallizes to solid toluene at -95 °C?

   (A) +69 J/mol-K   (B) +37 J/mol-K   (C) -37 J/mol-K   (D) -69 J/mol-K

10. The normal boiling point of toluene is 111 °C. The enthalpy of vaporization of toluene is 39.2 kJ/mol. What is the entropy change of the **surroundings** when one mole of toluene vaporizes at 111 °C?

   (A) -102 J/mol-K   (B) +35.3 J/mol-K   (C) +102 J/mol-K   (D) -353 J/mol-K

11. The reaction, A → B, is **endergonic** at 25 °C and the entropy change is +40 J/K. What can be concluded about the enthalpy change for this reaction?

   (A) $\Delta H < -11.9$ kJ   (B) $\Delta H > +11.9$ kJ   (C) $\Delta H > 18.4$ kJ
   (D) No conclusion can be made about ΔH

12. For the **exergonic** reaction, C → D, $\Delta H = +25$ kJ. For this reaction,

   (A) $\Delta G < 0$ & $\Delta S < 0$ (B) $\Delta G > 0$ & $\Delta S > 0$ (C) $\Delta G > 0$ & $\Delta S < 0$ (D) $\Delta G < 0$ & $\Delta S > 0$

13. The Enthalpy of Fusion of acetone is 5.7 kJ/mol. The Entropy of Fusion of Acetone is 32.0 J/mol-K. What is ΔG when 1 mole of liquid acetone is crystallized to the solid at 20 °C?

   (A) +3.7 kJ   (B) 0 kJ   (C) -3.7 kJ   (D) -15.1 kJ

14. The enthalpy and entropy changes for the denaturation of one mole of a protein, Native → Random Coil, are +280 kJ/mol and +800 J/mol-K, respectively. Over what temperature range, **in degrees Celsius**, is this transition spontaneous?

   (A) Below 77 °C   (B) Below 350 °C   (C) Above 77 °C   (D) Above 350 °C

15. The pairing of bases in the formation of doubly stranded DNA is

   (A) Favored by both ΔH and ΔS (B) Favored by ΔH, but not by ΔS
   (C) Favored by ΔS, but not by ΔH (D) Not favored by either ΔH or ΔS

16. Spooky McSchwartz (aka "The Spookman") recently developed a new, high efficiency, cycle for the metabolism of Swanson Chunk Tuna. In the MM cycle, $\Delta G°$ for the metabolism of one mole of Tuna is -1100 kJ and the cycle converts 25 moles of ADP to ATP. If $\Delta G° = 30$ kJ for the conversion of one mole of ADP to ATP, then the energy storage efficiency of Spooky's cycle is:

   (A) 83%   (B) 41%   (C) 28%   (D) 68%

For #17 - #19, consider the
phase diagram to the right
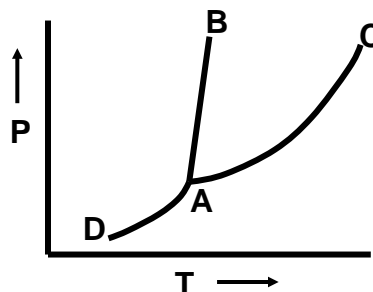
17. At temperatures below the triple point temperature, this substance can exist as:

    (A) vapor only   (B) solid or liquid or vapor

    (C) liquid or vapor only   (D) solid or vapor only

18. The slope of curve A-D is steeper than the slope of curve A-C because

    (A) $\Delta_{sub}S > \Delta_{vap}S$ (B) $\Delta_{vap}S > \Delta_{sub}S$ (C) $\Delta_{sub}V > \Delta_{vap}V$ (D) $\Delta_{sub}V < \Delta_{vap}V$

19. If the pressure on this substance is increased from 1 bar to 500 bar, the melting point will _____ and the boiling point will _____.

    (A) decrease, increase   (B) increase, increase (C) increase, decrease

    (D) increase/decrease depends on relative solid and liquid entropies, increase

_____

**PART II.   TWO (2) PROBLEMS ON FOLLOWING PAGES (Show work for partial credit)**

(10) 1. The normal boiling point of liquid pyridine is 116 °C*, and the Enthalpy of
Vaporization of pyridine is 40.3 kJ/mol.

Calculate the temperature, **in °C**, at which the vapor pressure of pyridine is 20 kPa.

*This is the temperature at which the vapor pressure of the liquid is 1.0 bar

(14) 2. The constant pressure molar heat capacity of benzene liquid [C_6H_6(liq)] is 135 J/mol-K. The melting point of benzene is 6 °C. The Enthalpy of Fusion of benzene is 9.8 kJ/mol. Consider the process in which **three (3)** moles of liquid benzene are (1) cooled from 70 °C to the melting point, and (2) is crystallized to the solid:

This two step process results in the transformation:

C_6H_6(liq, 70°C) → C_6H_6(sol, 6°C).
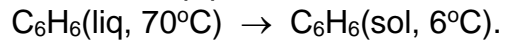
For this process, calculate:

(9) (a) ΔS (in J/K)

(5) (b) ΔH (in kJ)