Name_____

The Gas Constant is: $R = 8.31$ J/mol-K $= 8.31 \times 10^{-3}$ kJ/mol-K

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

1. The solubility of lead (II) arsenate, $Pb_3(AsO_4)_2$, in pure water is 3.3×10^{-8} M. The solublility product, K_{sp}, of lead (II) arsenate is approximately:

    (A) 1.4×10^{-36} (B) 3.9×10^{-38} (C) 2.8×10^{-36} (D) 4.2×10^{-36}

    For #2 - #3: consider the slightly soluble compound, $PbI_2(s)$. The solubility product (aka solubility constant) is $K_{sp} = 1.4 \times 10^{-8}$.

2. What is the Iodide concentration, $[I^-]$, when PbI_2 is dissolved in water?

    (A) 3.0×10^{-3} M   (B) 1.2×10^{-4} M   (C) 4.8×10^{-3} M   (D) 1.5×10^{-3} M

3. What is the solubility of $PbI_2(s)$ in a 0.01 M solution of the strong electrolyte, $Pb(NO_3)_2(aq)$?

    (A) 1.2×10^{-3} M   (B) 5.9×10^{-4} M   (C) 1.2×10^{-2} M   (D) 7.3×10^{-8} M

4. The solubility products of two sparingly soluble Bromide (Br^-) salts are:
    AgBr - $K_{sp} = 5.4 \times 10^{-13}$, $HgBr_2$ - $K_{sp} = 6.2 \times 10^{-20}$.

    Consider a solution which initially contains 5.0×10^{-5} M $Ag^+(aq)$ and 4.0×10^{-5} M $Hg^{2+}(aq)$. KBr (a strong electrolyte) is added until $[Br^-] = 5.0 \times 10^{-8}$ M. Which of the above salts will form any solid precipitate?

    (A) AgBr only   (B) $HgBr_2$ only   (C) Both AgBr and $HgBr_2$

    (D) Neither AgBr nor $HgBr_2$

5. Which of the following statements is/are correct?

    (1) The entropy change on condensing a gas is negative
    (2) The entropy usually decreases when a gas is dissolved in a liquid
    (3) The entropy of $CaCO_3(s)$ is higher than the entropy of $CaO(s)$
    (4) The entropy generally decreases when a solid dissolves in a liquid

    (A) 2 & 3 & 4   (B) 1 & 3   (C) 1 & 2 & 3   (D) 1 & 2 & 4

6. 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 **surroundings** when one mole of liquid toluene crystallizes to solid toluene at -95 °C?

    (A) -48.3 J/mol-K   (B) +37 J/mol-K   (C) +69 J/mol-K   (D) -37 J/mol-K

7. Consider the reaction: $2 Ca(s) + O_2(g) \rightarrow 2 MgO(s)$, $\Delta H° < 0$. This reaction is:

    (A) Reactant Favored at all temperatures

    (B) Product Favored at all temperatures

    (C) Product Favored at low temperature

    (D) Product Favored at high temperature

For #8 - #9: Consider the reaction: $2 SO_3(g) \rightarrow 2 SO_2(g) + O_2(g)$ at 25 °C

	SO₂(g)	**SO₃(g)**	**O₂(g)**
Sₘ°(25 °C)	248 J/mol-K	257 J/mol-K	205 J/mol-K
ΔGf°(25 °C)	-297 kJ/mol	-396 kJ/mol	

8. What is $\Delta G°$ for the above reaction [at 25 °C] ?

    (A) +198 kJ   (B) +99 kJ   (C) -198 kJ

    (D) Insufficient data is available

9. What is $\Delta H°$ for the above reaction [at 25 °C]?

    (A) -142 kJ   (B) +254 kJ   (C) +142 kJ

    (D) Insufficient data is available

10. For the hypothetical reaction, $A \rightleftharpoons B$, $\Delta H° = +50$ kJ/mol (independent of temperature). The equilibrium constant for the reaction at 400 °C is 1.0×10^{-8}. What is the entropy change, $\Delta S°$ for this reaction?

    (A) -28 J/K   (B) +79 J/K   (C) -42 J/K   (D) -79 J/K

11. The reaction $A \rightarrow B$ is **exergonic** at 25 °C and the enthalpy change is +45 kJ. What can be concluded about the entropy change for this reaction?

    (A) $\Delta S < -70$ J/K   (B) $\Delta S > +150$ J/K

    (C) $\Delta S < -150$ J/K   (C) $\Delta S = \dfrac{\Delta H}{T}$

12. For the **_endergonic_** reaction, $C \rightarrow D$, $\Delta S = +50$ J/K For this reaction,

    (A) $\Delta G>0$ & $\Delta H>0$ (B) $\Delta G>0$ & $\Delta H<0$

    (C) $\Delta G<0$ & $\Delta H>0$ (D) $\Delta G<0$ & $\Delta H<0$

13. Consider the reaction, $2 HI(g) \rightleftharpoons H_2(g) + I_2(s)$ at 25 °C. The Gibbs Free Energy of Formation of HI(g) is +1.70 kJ/mol. Therefore, the equilibrium constant for the above reaction at 25 °C is approximately:

    (A) 0.25   (B) 2.0   (C) 3.9   (D) 2.4

14. For the reaction, $2\ C_2H_2(g) + 4\ H_2(g) \rightarrow 2\ C_2H_6(g)$, $\Delta S° = -470$ J/K and $\Delta H° = -620$ kJ. What is the entropy change of the **system**, ΔS_{sys}, for the related reaction, $C_2H_6(g) \rightarrow C_2H_2(g) + 2\ H_2(g)$ at 25 °C?

   (A) +235 J/K   (B) +1040 J/K   (C) +470 J/K   (D) -1040 J/K

For #15 - #16: The Enthalpy of Fusion of I_2(sol) is 7.80 kJ/mol. The Entropy of Fusion of I_2(sol) is 19.6 J/mol-K.

15. The Entropy change of the universe, ΔS_{univ}, when one mole of I_2(liq) crystallizes to I_2(sol) at 80 °C is approximately:

   (A) -2.5 J/mol-K   (B) +7.7 J/mol-K   (C) +2.5 J/mol-K

   (D) None of the above

16. The Gibbs Energy Change, $\Delta G°$, when 1 mole of I_2(liq) crystallizes to I_2(sol) at 150 °C is approximately:

   (A) -0.5 kJ/mol   (B) -4.9 kJ/mol   (C) +4.9 kJ/mol   (D) +0.5 kJ/mol

17. In class we discussed the transformation of a protein (e.g. Ribonucleus) between the Native and Random Coil forms with variation in temperature. Consider a hypothetical protein with two native forms, α and β. For the transition from the α to the β structure, $\alpha \rightarrow \beta$, the enthalpy and entropy changes are: $\Delta H° = -140$ kJ/mol and $\Delta S° = -420$ J/mol-K. For this protein, the _____ form is the more stable one at all temperatures **above** _____ °C.

   (A) α , 60 °C   (B) α , 333 °C   (C) β , 47 °C   (D) β , 60 °C

18. In class, we discussed the thermodynamics involved in Base Pairing in the formation of Doubly-Coiled DNA from the individual DNA strands. Consider the denaturation of a DNA double coil. This involves the breaking of base pairs such as Cytosine-Guanine (C-G). For the **breaking** of one of these base pairs, i.e. C-G $\rightarrow$ C + G, the process is _____ by $\Delta H°$ and _____ by $\Delta S°$.

   (A) favored, favored   (B) favored, disfavored

   (C) disfavored, favored   (D) disfavored, disfavored

19. Regarding the following reaction, which of the statements below is/are correct?

   $$Fe_2S_3(s) + 3\ GeS(g) \rightarrow 2\ Fe + 3\ GeS_2(g)$$

   (1) Fe_2S_3 is the oxidizing agent   (2) GeS_2 is oxidized
   (3) 3 electrons are transfered   (4) GeS is reduced

   (A) 2 & 4   (B) 1 & 3   (C) 1 & 2 & 3   (D) 1 only

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PART II.   TWO (2) PROBLEMS : REMEMBER TO SHOW WORK FOR CREDIT

The Gas Constant is: $R = 8.31$ J/mol-K $= 8.31 \times 10^{-3}$ kJ/mol-K

(14) 1. For the reaction, $2\,NH_3(g) \rightleftharpoons N_2(g) + 3\,H_2(g)$, $\Delta H^\circ = +92$ kJ and $\Delta S^\circ = +360$ J/K.

   (6) (a) Calculate the equlibrium constant, K, for this reaction at 50 °C, **in kJ**.

   (4) (b) Calculate the value of ΔG for this reaction at 50 °C when the pressures are: $P(N_2) = P(H_2) = 15.0$ bar, $P(NH_3) = 0.10$ bar.

   (4) (c) Calculate the temperature, **in °C**, at which reactants and products are in equilibrium under standard conditions. Is the reaction **Reactant favored** or **Product favored** at temperatures higher than this.

(10) 2. Balance the following oxidation-reduction reaction in **aqueous Basic** solution.

$$Mo_2O_7^{2-} + SO_2 \rightarrow Mo^{3+} + SO_4^{2-}$$
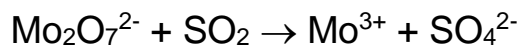
Name_____

The Gas Constant is: R = 8.31 J/mol-K = 8.31x10^{-3} kJ/mol-K

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

For #1 - #2: consider the slightly soluble compound, PbI_2(s). The solubility product (aka solubility constant) is K_{sp} = 1.4x10^{-8}.

1.   What is the Iodide concentration, [I$^-$], when PbI_2 is dissolved in water?

    (A) 4.8x10^{-3} M   (B) 1.2x10^{-4} M   (C) 3.0x10^{-3} M   (D) 1.5x10^{-3} M

2.   What is the solubility of PbI_2(s) in a 0.01 M solution of the strong electrolyte, $Pb(NO_3)_2$(aq)?

    (A) 1.2x10^{-3} M   (B) 7.3x10^{-8} M   (C) 1.2x10^{-2} M   (D) 5.9x10^{-4} M

3.   The solubility of lead (II) arsenate, $Pb_3(AsO_4)_2$, in pure water is 3.3x10^{-8} M. The solublility product, K_{sp}, of lead (II) arsenate is approximately:

    (A) 4.2x10^{-36} (B) 3.9x10^{-38} (C) 2.8x10^{-36} (D) 1.4x10^{-36}

4.   The solubility products of two sparingly soluble Bromide (Br$^-$) salts are:
AgBr - K_{sp} = 5.4x10^{-13} , $HgBr_2$ - K_{sp} = 6.2x10^{-20}.

    Consider a solution which initially contains 5.0x10^{-5} M Ag$^+$(aq) and 4.0x10^{-5} M Hg^{2+}(aq). KBr (a strong electrolyte) is added until [Br$^-$] = 5.0x10^{-8} M. Which of the above salts will form any solid precipitate?

    (A) AgBr only   (B) $HgBr_2$ only   (C) Neither AgBr and $HgBr_2$

    (D) Both AgBr and $HgBr_2$

5.   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 **surroundings** when one mole of liquid toluene crystallizes to solid toluene at -95 °C?

    (A) -48.3 J/mol-K   (B) +37 J/mol-K   (C) +69 J/mol-K   (D) -37 J/mol-K

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    (3) The entropy of $CaCO_3$(s) is higher than the entropy of CaO(s)
    (4) The entropy generally decreases when a solid dissolves in a liquid

    (A) 2 & 3 & 4   (B) 1 & 3   (C) 1 & 2 & 3   (D) 1 & 2 & 4

For #7 - #8: Consider the reaction: $2 SO_3(g) \rightarrow 2 SO_2(g) + O_2(g)$ at 25 °C

	$SO_2(g)$	$SO_3(g)$	$O_2(g)$
$S_m°(25 °C)$	248 J/mol-K	257 J/mol-K	205 J/mol-K
$\Delta G_f°(25 °C)$	-297 kJ/mol	-396 kJ/mol	

7. What is $\Delta G°$ for the above reaction [at 25 °C] ?

(A) -198 kJ   (B) +99 kJ   (C) +198 kJ

(D) Insufficient data is available

8. What is $\Delta H°$ for the above reaction [at 25 °C]?

(A) +254 kJ   (B) -142 kJ   (C) +142 kJ

(D) Insufficient data is available

9. Consider the reaction: $2 Ca(s) + O_2(g) \rightarrow 2 MgO(s)$, $\Delta H° < 0$. This reaction is:

(A) Reactant Favored at all temperatures

(B) Product Favored at all temperatures

(C) Product Favored at high temperature

(D) Product Favored at low temperature

10. Consider the reaction, $2 HI(g) \rightleftharpoons H_2(g) + I_2(s)$ at 25 °C. The Gibbs Free Energy of Formation of HI(g) is +1.70 kJ/mol. Therefore, the equilibrium constant for the above reaction at 25 °C is approximately:

(A) 0.25   (B) 3.9   (C) 2.4   (D) 2.0

11. For the **endergonic** reaction, $C \rightarrow D$, $\Delta S = +50$ J/K For this reaction,

(A) $\Delta G<0$ & $\Delta H<0$ (B) $\Delta G>0$ & $\Delta H<0$

(C) $\Delta G<0$ & $\Delta H>0$ (D) $\Delta G>0$ & $\Delta H>0$

12. The reaction $A \rightarrow B$ is **exergonic** at 25 °C and the enthalpy change is +45 kJ. What can be concluded about the entropy change for this reaction?

(A) $\Delta S > +150$ J/K   (B) $\Delta S < -150$ J/K

(C) $\Delta S < -70$ J/K   (C) $\Delta S = \dfrac{\Delta H}{T}$

13. For the hypothetical reaction, $A \rightleftharpoons B$, $\Delta H° = +50$ kJ/mol (independent of temperature). The equilibrium constant for the reaction at 400 °C is 1.0×10^{-8}. What is the entropy change, $\Delta S°$ for this reaction?

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    (A) +2.5 J/mol-K   (B) +7.7 J/mol-K   (C) -2.5 J/mol-K

    (D) None of the above

16. The Gibbs Energy Change, ΔG^o, when 1 mole of I_2(liq) crystallizes to I_2(sol) at 150 °C is approximately:

    (A) -0.5 kJ/mol   (B) -4.9 kJ/mol   (C) +0.5 kJ/mol   (D) +4.9 kJ/mol

14. For the reaction, $2\ C_2H_2(g) + 4\ H_2(g) \rightarrow 2\ C_2H_6(g)$, ΔS^o = -470 J/K and ΔH^o = -620 kJ. What is the entropy change of the **system**, ΔS_{sys}, for the related reaction, $C_2H_6(g) \rightarrow C_2H_2(g) + 2\ H_2(g)$ at 25 °C?

    (A) +1040 J/K   (B) +235 J/K   (C) +470 J/K   (D) -1040 J/K

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    (A) β , 60 °C   (B) α , 333 °C   (C) β , 47 °C   (D) α , 60 °C

19. Regarding the following reaction, which of the statements below is/are correct?

    $$Fe_2S_3(s) + 3\ GeS(g) \rightarrow 2\ Fe + 3\ GeS_2(g)$$

    (1) Fe_2S_3 is the oxidizing agent   (2) GeS_2 is oxidized
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    (A) 2 & 4   (B) 1 & 2 & 3   (C) 1 only   (D) 1 & 3

_____

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(6) (a) Calculate the equlibrium constant, K, for this reaction at 60 °C, **in kJ**.

(4) (b) Calculate the value of ΔG for this reaction at 60 °C when the pressures are: $P(N_2) = P(H_2) = 12.0$ bar, $P(NH_3) = 0.10$ bar.

(4) (c) Calculate the temperature, **in °C**, at which reactants and products are in equilibrium under standard conditions. Is the reaction **Reactant favored** or **Product favored** at temperatures higher than this.

(10) 2.   Balance the following oxidation-reduction reaction in **aqueous Basic** solution.

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