Constants and Conversion Factors

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

1 bar = 100 kPa

1 kPa = 7.50 torr

1 J = 1 kPa-L

N_A = 6.02x10^{23} mol^{-1} (Avogadro's Number)

Molar Masses: Given in each question that requires the Molar Mass

Name_____

If you wish to have your final exam and course grade posted on the Web site, please provide me with a four (4) digit number which will be the ID number for your grade.

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Four (4) digit number for posting.

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

1. How many hydrogen atoms are contained in 34 grams of NH_3 (M=17)?

    (A) 4.0×10^{23} (B) 4.8×10^{34} (C) 1.2×10^{24} (D) 3.6×10^{24}

2. The pressure of a sample of $O_2(g)$ is 150 torr at 200 °C in a 10 L container. What is the pressure of this gas at 50 °C in a 2 L container?

    (A) 1100 torr   (B) 510 torr   (C) 190 torr   (D) 20 torr

3. How many grams of $O_2(g)$ (M=32) are contained in a 15.0 L vessel at 0.70 bar and 150 °C?

    (A) 9.6 g   (B) 0.30 g   (C) 26.9 g   (D) 0.096 g

4. A sample of $CO_2(g)$ (M=44) effuses through a pinhole in 120 s. The same amount of an unknown gas effuses through the pinhole in 160 s. The Molar Mass of the unknown gas is

    (A) 78 g/mol   (B) 59 g/mol   (C) 51 g/mol   (D) 25 g/mol

5. The constant pressure molar heat capacity of $CO_2(g)$ is 37.1 J/mol-K. When 5.0 kJ of heat is added at constant pressure to a 110 g sample of $CO_2(g)$ (M=44) initially at 50 °C, the final temperature is

    (A) 54 °C   (B) 68 °C   (C) 104 °C   (D) 377 °C

6. When a gas is cooled at constant pressure, :

    (A) $w < 0$, $\Delta H < 0$ (B) $w > 0$, $\Delta H < 0$
    (C) $w < 0$, $\Delta H > 0$ (D) $w = 0$, $\Delta H < 0$

7. When a gas is expanded isothermally and reversibly,

    (A) $q<0$ and $\Delta U<0$ (B) $q<0$ and $\Delta U=0$
    (C) $q>0$ and $\Delta U<0$ (D) $q>0$ and $\Delta U=0$

8. For a process in which the internal energy change of a gas is **positive**, which of the following processes is/are possible?

   (i)   the gas is expanded and cooled
   (ii) the gas is compressed and heated
   (iii) the gas is expanded and heated

   (A) i only   (B) ii only   (C) i and iii   (D) ii and iii

9. What is the work involved when 230 g of liquid toluene, C_7H_8 (M=92) is vaporized at 1 bar and 111 °C?

   (A) +2.3 kJ   (B) -8.0 kJ   (C) -2.3 kJ   (D) +8.0 kJ

10. The enthalpy of vaporization of benzene is 30.8 kJ/mol. What is ΔH when 234 grams of benzene vapor (M=78) is condensed to the liquid phase at 80 °C (its normal boiling point)?

    (A) -92.4 kJ   (B) -10.3 kJ   (D) +92.4 kJ   (D) -8.8 kJ

11. From the following thermochemical equations,

$$2\ H_2O(g) \rightarrow 2\ H_2(g) + O_2(g) \qquad \Delta H= +484\ kJ$$
$$2\ O_3(g) \rightarrow 3\ O_2(g) \qquad \Delta H= +286\ kJ$$

    ΔH for the reaction, $3\ H_2(g) + O_3(g) \rightarrow, 3\ H_2O(g)$ is

    (A) +869 kJ   (B) -341 kJ   (C) +583 kJ   (D) -583 kJ

12. 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 heated from 50 °C to 200 °C at 1 bar?

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

13. 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 volume of 25 L. What is ΔS for this process?

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

14. 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 Isolid toluene melts to liquid toluene at -95 °C?

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

15. The enthalpy of fusion of chloroform, mercury is 2.3 kJ/mol. What is the entropy change of the **surroundings** when 4 moles of mercury liquid are frozen (i.e. crystallized) to the solid at -39 °C?

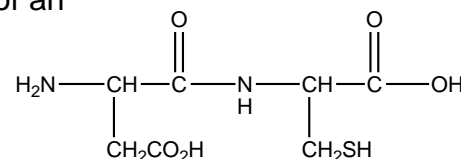   (A) +9.8 J/K   (B) +39.3 J/K   (C) -9.8 J/K   (D) -39.3 J/K

16. The entropy change for the **endergonic** reaction, A → B, is +120 J/K. What can you say about the enthalpy change for this reaction at 27 °C?

(A) $\Delta H > +36$ kJ   (B) $\Delta H > -36$ kJ   (C) $\Delta H < +36$ kJ
(D) Insufficient information is available

17. 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) $\Delta G>0$ & $\Delta S>0$

18. When 60 grams of glucose (M=180) is added to 150 grams of water (M=18), the density of the solution is 1.15 g/mL. What is the Molarity of the above solution?

(A) 2.6 Molar   (B) 2.4 Molar   (C) 2.2 Molar   (D) 1.8 Molar

19. When 37 grams of the strong electrolyte, $Mg(NO_3)_2$ [M=148], is dissolved in 125 grams of H_2O (K_f 1.9 °C/m), the freezing point of the solution is:

(A) -11.4 °C   (B) +3.8 °C   (C) -7.6 °C   (D) -3.8 °C

20. When 25 grams of an unknown compound is dissolved in 500 g of water (K_f=1.9 °C/m), the freezing point of the solution is -1.10 °C. The Molar Mass of the compound is approximately

(A) 58 g/mol   (B) 29 g/mol   (C) 105 g/mol   (D) 86 g/mol

21. When 2.0 grams of sucrose (M = 342) is dissolved in 500 mL of aqueous solution, what is the osmotic pressure of the solution at 60 °C, in bar?

(A) 0.06 bar   (B) 0.32 bar   (C) 5.8 bar   (D) 32.4 bar

For #22 - #26: Consider the gas phase equilibrium, $2\ POCl_3(g) = 2\ PCl_3(g) + O_2(g)$. The enthalpy change for this reaction is +510 kJ, and the equilibrium constant at 27 °C is K = 25.

22. For the above reaction, if the temperature is **decreased**,

(A) the equilibrium will move to the left and K will decrease
(B) the equilibrium will move to the right and K will increase
(C) the equilibrium will move to the left and K will remain constant
(D) the equilibrium will move to the right and K will remain constant

23. For the above reaction, if the volume is **increased**,

(A) the equilibrium will move to the left and K will decrease
(B) the equilibrium will move to the right and K will increase
(C) the equilibrium will move to the left and K will remain constant
(D) the equilibrium will move to the right and K will remain constant

24. What is ΔG for this reaction at 27 °C when P_{POCl3} = 0.1 bar and P_{PCl3} = P_{Cl2} = 3.0 bar?

(A) -8.0 kJ   (B) -19.7 kJ   (C) +11.7 kJ   (D) +19.7 kJ

25. For the reaction, $PCl_3(g)$ + (1/2) $Cl_2(g)$ = $POCl_3(g)$, the equilibrium constant at 27 °C is

(A) 0.20   (B) 0.04   (C) 5.0   (D) 1.6×10^{-3}

26. What is the value of the equilibrium constant for the original reaction,   2
$POCl_3(g)$ = 2 $PCl_3(g)$ + $Cl_2(g)$, at 47 °C?

(A) 7.0×10^{-5} (B) 2.6×10^{4} (C) 100   (D) 8.9×10^{6}

27. The gas phase molecule, A, dissociates according to the equilibrium,

$A(g)$ = $B(g)$ + 3 $C(g)$. The equilibrium constant is 1×10^{-3}. If one puts an initial pressure of 5 bar of A into a flask, what is the pressure of B at equilibrium?

[**NOTE**: You may assume that very little A dissociates]

(A) 0.27 bar   (B) 0.12 bar   (C) 0.08 bar   (D) 0.36 bar

For #28 - #30: Pyridine (Pyr) is a weak base with a base equilibrium constant, $K_b = 1.7 \times 10^{-9}$.

28. What is the approximate pH of a 0.20 M solution of pyridine (Pyr)?

(A) 9.3   (B) 4.7   (C) 4.4   (D) 9.6

29. What is the approximate pH of a 0.04 M solution of pyridinium chloride (PyrHCl)?

(A) 3.3   (B) 5.1   (C) 8.9   (D) 10.7

30. What is the approximate pH after 120 mL of 1.00 M of NaOH is added to 500 mL of a 0.40 M solution of aqueous pyridinium chloride?

(A) 9.0   (B) 5.1   (C) 8.6   (D) 5.4

For #31 - #33: Consider the dipeptide (Pep) consisting of an Aspartic Acid residue and a Cysteine residue (pictured on right)
Note: The most positive form of the peptide has a charge of +1

The two side groups ionize according to:

$-CH_2CO_2H \rightleftharpoons H^+ + -CH_2CO_2^-$ and $-CH_2SH \rightleftharpoons H^+ + -CH_2S^-$
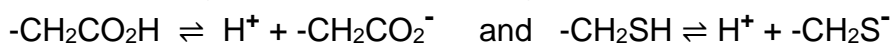
The four pK_a's are: pK_a' (α-CO_2H) = 1.9, pK_a'' (β-CO_2H) = 3.9, pK_a''' (CH_2SH) = 8.5 and pK_a'''' (α-NH_3^+) = 9.9

31. What is the pH after 2.0 equivalents of NaOH are added to a solution containing the most acidic form of Pep?

    (A) 2.9   (B) 3.9   (C) 6.2   (D) 8.5

32. What pH corresponds to the isoelectric point, pI, of Pep?

    (A) 2.9   (B) 3.9   (C) 6.2   (D) 9.2

33. What is the average charge of Pep at pH = 8.5?

    (A) -2.5   (B) -0.5   (C) -2.0   (D) -1.5

34. Consider a 5/2 order reaction; i.e. R = $k[A]^{5/2}$. When the initial concentration is $[A_o]$ = 0.05 M, the initial rate is 12. Ms^{-1}. What is the approximate value of the rate constant (in units of $M^{-3/2}s^{-1}$) ?

    (A) 4.7×10^{-5} (B) 6.7×10^{-3} (C) $1.1 \times 10^{+5}$ (D) $2.1 \times 10^{+4}$

35. The reaction, A $\rightarrow$ Products, is of order "x"; i.e. rate = $k[A]^x$. When $[A_o]$= 0.25 M, the half-life of the reaction is 400 s. When $[A_o]$= 0.50 M, the half life of the reaction is 100 s. The order of the reaction, x, is

    (A) 4   (B) 3   (C) 2   (D) -2

36. Consider the second order reaction, A $\rightarrow$ Products. The rate constant is k= 0.10 $M^{-1}s^{-1}$, and the initial concentration is $[A]_0$= 0.50 M. What is the concentration of A 30 seconds after the start of the reaction?

    (A) 0.20 M   (B) 0.125 M   (C) 0.24 M   (D) 0.36 M

37. A reaction proceeds by the two step mechanism: (1) $A_2 \rightleftharpoons 2$ A (fast pre-equilibrium, characterized by the equilibrium constant, K) and (2) A + B $\rightarrow$ Product (Slow Rate-Determining Step, characterized by rate constant, k). The rate law for the formation of product is of the form:

    (A) $k_{eff}[A_2]^2[B]$ (B) $k_{eff}[A_2][B]$ (C) $k_{eff}[A_2]^{1/2}[B]$ (D) $k_{eff}[A_2][B]^{1/2}$

38. For an enzyme catalyzed reaction, when the substrate concentration, $[S] = 3K_M$, then the initial velocity, v_0 is

(A) $0.25V_m$ (B) $0.67\ V_m$ (C) $0.75V_m$ (D) $1.33V_m$

For #39 - #40: Consider an enzyme catalyzed reaction with $[E]_o = 2$ mM, $K_M = 20$ mM, and $V_M = 80$ mM/s

39. The slope of the Lineweaver-Burk plot is

(A) 0.013 s/mM   (B) $4\ s^{-1}$ (C) 6.3×10^{-4} mM/s   (D) 0.25 s

40. The intercept of the Lineweaver-Burk plot is

(A) 0.013 s/mM   (B) $4\ s^{-1}$ (C) 6.3×10^{-4} mM/s   (D) 0.25 s

41. When an inhibitor is added to an enzyme catalyzed reaction, it is found that the slope of the Lineweaver-Burk plot is increased, but the intercept remains unchanged. Therefore, the type of inhibition is

(A) Noncompetitive   (B) Uncompetitive   (C) Competitive   (D) Briggs-Haldane

For #42 - #43: Consider an enzyme catalyzed reaction with $K_M = 25$ mM, $V_m = 100\ \mu$M/s, and $[S] = 40$ mM. A **Competitive** inhibitor to this reaction has an inhibitor constant, $K_I = 10$ mM.

42. What is the initial velocity, v_0, in the absence of the inhibitor?

(A) 62 mM/s   (B) 54 mM/s   (C) 38 mM/s   (D) 83 mM/s

43. What is the percent inhibition (i%) when the inhibitor concentration is $[I] = 30$ mM?

(A) 36%   (B) 46%   (C) 54%   (D) 64%

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(30)   **PART II. THREE (3) PROBLEMS FOLLOW (Show work for partial credit)**

(08) 1. The reaction, $2B + C \rightarrow P$ (P is the product) proceeds by the following mechanism.

$$2B \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} I \qquad \text{followed by} \qquad I + C \xrightarrow{k_2} P$$

"**I**" is an intermediate present in steady-state concentration. Use the steady-state approximation on [**I**] to develop an expression for the rate of formation of P as a function of [B], [C], k_1, k_{-1} and k_2.

(10) 2. The rate constant for a first order reaction is 2.5 s^{-1} at 30 °C and the Activation Energy is 75 kJ/mol. Calculate the temperature, **in °C**, at which the rate constant will be 100. s^{-1}.

(12) 3. An enzyme has the Michaelis-Menten parameters, K_M= 60 mM and V_m= 100 μM/min. The inhibition equilibrium constant for **Uncompetitive** inhibition is K_I = 10 mM. When [S]= 30 mM, calculate the inhibitor concentration, [I], **in mM**, required to get 75% inhibition (i.e. i%=75) for this **Uncompetitive** inhibitor.