Print Name: _____ _____
Last Name First Name

Teaching Assistant _____ Section _____

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Directions:

1. The exam has 61 multiple choice questions that are equally weighted at 5 points each.
2. A calculator and a four page crib sheet (8.5 x 11, front only) are permitted for use during the exam.
3. Complete the scantron card and include, your name, your TA, your lecture professor, your GT ID (bubble in the appropriate numbers), and the exam version. All of this material must be submitted to receive credit.
4. Cell phones must be shut off during the exam.
5. A maximum of 170 minutes is allowed for the exam.
6. When you are finished or when time is called, submit your exam to your TA, show your buzz card or other photo ID for identification.
7. You may not leave the exam room until 50 minutes have lapsed.
8. A periodic table is provided at the end of the exam.
9. Only the answers submitted on the scantron card will be graded.

Section 1 (questions 1-14)

1. How many orbitals are contained in the third shell (n = 3) of a given atom?
   A) 18
   B) 7
   C) 3
   D) 9
   E) 5

Answer: D

2. Oxygen has ___ valence electrons.
   A) 5
   B) 4
   C) 6
   D) 7
   E) 2

Answer: C

3. Place the following in order of ionic radius:

Br^- Na^+ Rb^+

Smallest to Largest

A) $Na^+ < Rb^+ < Br^-$
B) $Br^- < Na^+ < Rb^+$
C) $Rb^+ < Br^- < Na^+$
D) $Br^- < Rb^+ < Na^+$
E) $Rb^+ < Na^+ < Br^-$

Answer:A

4. Place the following bonds in order of ionic character:

Si – P Si – Cl Si – S

Smallest to Greatest

A) Si-P < Si-S < Si-Cl
B) Si-Cl < Si-S < Si-P
C) Si-Cl < Si-P < Si-S
D) Si-S < Si-Cl < Si-P
E) Si-P < Si-Cl < Si-S

Answer: A

5. Which of the following electronic transitions of a hydrogen atom would yield the longest wavelength of light as a result of atomic emission?
   A) n = 4 to n = 2
   B) n = 3 to n = 4
   C) n = 5 to n = 4
   D) n = 1 to n = 2
   E) n = 3 to n = 1

Answer: C

6. Identify the spectator ion(s) in the following molecular equation:

   $KBr\ (aq) + AgNO_3\ (aq) \rightarrow AgBr\ (s) + KNO_3\ (aq)$

   A) NO_3^- only
   B) K^+ and Br^-
   C) Ag^+ and NO_3^-
   D) Ag^+ and Br^-
   E) K^+ and NO_3^-

Answer: E

7. Which solution has the greatest concentration of chloride ions (Cl^-)?
   A) 0.06 M $MgCl_2$
   B) 0.05 M $CaCl_2$
   C) 0.13 M NaCl
   D) 0.04 M CCl_4
   E) 0.05 M $AlCl_3$

Answer: E
CCl_4 is a covalent molecule that does not dissociate.

8. Consider the following reaction:

   $CH_4(g) + 4Cl_2(g) \rightarrow CCl_4(g) + 4HCl(g)$

   What mass of CCl_4 will be formed if 1.20 moles of methane (CH_4) react with 1.60 moles of chlorine?
   A) 229 g
   B) 61.5 g
   C) 114 g
   D) 171 g
   E) 17.1 g

Answer: B

9. How many liters of a 0.0555 M KCl solution contain 0.163 moles of Cl^- ?
   A) 2.95 L
   B) 3.37 L
   C) 1.12 L
   D) 1.48 L
   E) 8.98 L

Answer: A

10. What is the oxidation state of "P" in PO_3^{3-} ?
    A) 0B) +6
    C) -3
    D) +3
    E) +2

Answer: D

11. Determine the molecular formula of a compound that has a molecular weight of 366 g/mol and an empirical formula of $C_2H_5O_2$.
    A) $C_3H_7O_3$
    B) $C_6H_{15}O_6$
    C) $C_{12}H_{30}O_{12}$
    D) $C_2H_5O_2$
    E) $C_8H_{20}O_8$

Answer: C

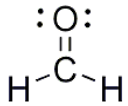
12. The ratio of the number of bismuth atoms to the number of oxygen atoms in Bi2(SO4)3 is:
    A) 1:6
    B) 2:7
    C) 2:3
    D) 2:1
    E) none of these

Answer: A

13. Which species below is <u>trigonal planar</u>?
    A) NH_4^+
    B) SO_3^{2-}
    C) CO_3^{2-}
    D) NH_3
    E) ClO_3^-

Answer: C

14. The bond angles about the carbon atom in the formaldehyde molecule ($H_2C{=}O$, below) are:



    A) ≈120°
    B) ≈109°
    C) ≈180°
    D) ≈60°
    E) ≈90°

Answer: A

Section 2 (questions 15-28)

15. Determine the pH of a 50 mL 0.116 M NaOH solution after dilution by the addition of 100 mL of water.

A) 13.1
B) 13.4
C) 11.4
D) 12.6
E) 12.9
Answer: D

16. Determine the volume of SO_2 (at STP= 273K, 1 atm) formed from the complete reaction of 96.7 grams of FeS_2 (molecular weight = 120 g/mol) and 55.0 L of O_2 (398 K, 1.20 atm).

$$4\ FeS_2\ (g) + 11\ O_2\ (g) \rightarrow 2\ Fe_2O_3\ (s) + 8\ SO_2\ (g)$$

A) 36.1 L
B) 27.6 L
C) 18.1 L
D) 45.3 L
E) 32.9 L
Answer: E
4 FeS2 (g) + 11 O2 (g) → 2 Fe2O3 (s) + 8 SO2 (g)
FeS2: (96.7 g)[4(120 g/mol)]-1 = 0.20 mol
O2: (55.0 L)(1.2 atm) [11(0.082 L-atm/mole-K)(398 K)] -1= 0.18 mol
O2 is the limiting reagent.
Use V = nRT/P = 8(0.18mol)(0.082 L-atm/mole-K)(273 K)(1.0 atm)-1 = 32.3 L

17. What is the conjugate <u>acid</u> of H_2O ?

A) H_3O^+
B) PO_4^{3-}
C) H_2OD) $H_2PO_4^-$
E) OH^-
Answer: A

18. Which of the following statements is TRUE?

A) The equilibrium constant for the forward reaction is equal to the equilibrium constant for the reverse reaction.
B) Equilibrium indicates that the amounts of reactants and products are equal.
C) When the reaction quotient (Q) is larger than the equilibrium constant, the reaction will be proceed in the forward direction.
D) The forward and reverse reactions stop at equilibrium.
E) The reaction shows no macroscopic evidence of change at equilibrium.
Answer: E,
C is incorrect. When Q>K, the reaction goes backward.

19. To increase the value of K for the following exothermic reaction

$2H_2(g) + O_2(g) \rightleftharpoons H_2O(g)$

A) increase the total pressure.
B) decrease the total pressure.
C) decrease the temperature.
D) increase the temperature.
E) add H_2.

Answer: C the reaction evolves heat. Remove heat from the system to drive it forward.

20. Which of the following exhibits the correct ranking of atomic radius and first ionization energy?

A) Atomic Radius: S < O< F and Ionization Energy: F < O < S
B) Atomic Radius: S < O< F and Ionization Energy: O < S < F
C) Atomic Radius: S < F < O and Ionization Energy: S < F < O
D) Atomic Radius: F < O < S and Ionization Energy: S < O< F
E) Atomic Radius: F < O < S and Ionization Energy: O < S < F

Answer: D

21. Place the following three substances in order of increasing boiling point.

$CH_3CH_2OCH_2CH_3$	Ar	CH_3OCH_3

smallest to largest

A) Ar < CH_3OCH_3 < $CH_3CH_2OCH_2CH_3$
B) $CH_3CH_2OCH_2CH_3$ < Ar < CH_3OCH_3
C) Ar < $CH_3CH_2OCH_2CH_3$ < CH_3OCH_3
D) $CH_3CH_2OCH_2CH_3$ < CH_3OCH_3 < Ar
E) CH_3OCH_3 < Ar < $CH_3CH_2OCH_2CH_3$

Answer: A

22. Consider the following reaction at equilibrium. What effect will reducing the volume of the reaction mixture have on the system?

$$2\ HBr(g) \rightleftharpoons H_2(g) + Br_2(g)$$

A) The reaction will shift to the left
B) The reaction will shift to the right
C) The equilibrium constant will decrease
D) The equilibrium constant will increase
E) No effect

Answer: E

23. What is the pH of pure water at 40°C if the K_w at this temperature is 2.92×10^{-14}?
A) 0.47
B) 8.45
C) 7.00
D) 6.77
E) 7.23
Answer: D

24. What is the volume of 0.780 moles of He (g) at STP (273K, 1 atm) ?
A) 43.7 L
B) 70.0 L
C) 17.5 L
D) 15.6 L
E) 22.4 L
Answer: C

25. What is the pH of a 0.2 M solution of NH_4Cl (aq)? K_b for NH_3 is 1.8×10^{-5}.
A) 2.7
B) 5.0
C) 7.0
D) 9.0
E) 11.3
Answer: B
Kw = Kb/Ka; Ka = 5.6 x 10-10
pH = - log (SQRT(5.6 x 10-10 x 0.2)) = 5.0

26. To calculate the freezing point of an ideal dilute solution containing a single non-dissociating solute, the minimum information one must know is
I the molality
II the molarity
III the freezing-point-depression constant of the solvent.
IV the freezing point of the pure solvent.
V the molecular weight of the solute.

A) I, III
B) II, III
C) II, III, IV, V
D) I, III, IV
E) II, III, IV
*Answer: D

27. For the reactions 1 and 2, $K_1 = 10^2$ and $K_2 = 10^{-4}$.

    1. $A_2(g) + B_2(g) \rightleftharpoons 2AB(g)$
    2. $2A_2(g) + C_2(g) \rightleftharpoons 2A_2C\ (g)$
    3. $A_2C\ (g) + B_2(g) \rightleftharpoons 2AB(g) + (1/2)C_2(g)$

    What is K_3 ?

    A) 10^4
    B) 10^{-2}
    C) 10^6
    D) 10^2
    E) 10^{-4}

Answer: A
Reaction 3 = reaction 1 -1/2(reaction 2)

28. The boiling point of pure benzene at 760 torr is 80.1°C. What is the vapor pressure of benzene over an *ideal* solution containing 1.00 mole of a nonvolatile solute and 12.0 moles of benzene at 80.1°C?

    A)
    B) 695 torr 823 torr
    C) 760 torr
    D) 702 torr
    E) 63.0 torr

Answer: D

Section 3 (questions 29-42)

29. Using the following data, calculate the standard heat of formation of two moles of the compound ICl (g) from I_2 (g) and Cl_2 (g):

	$\Delta H°$ (kJ/mol)
$Cl_2(g) \rightarrow 2Cl(g)$	242
$I_2(g) \rightarrow 2I(g)$	150
$ICl(g) \rightarrow I(g) + Cl(g)$	211
$I_2(s) \rightarrow I_2(g)$	63

A) –211 kJ/mol
B) –15 kJ/mol
C) +30 kJ/mol
D) -30 kJ/mol
E) 181 kJ/mol

Answer: D

$Cl_2(g) \rightarrow 2Cl(g)$ $\Delta H° = 242$

$I_2(g) \rightarrow I(g)$ $\Delta H° = 150$

$2Cl(g) + 2I(g) \rightarrow 2ICl(g)$ $\Delta H° = -422$

$I_2(g) + Cl_2(g) \rightarrow 2ICl(g)$ $\Delta H° = 242 + 150 - 422 = -30$ kJ/mol

30. For the reaction A + B → C + D,
$\Delta H° = 40$ kJ/mol and $\Delta S° = 50$ J/mol-K.
The reaction under standard conditions is
A) spontaneous reverse at temperatures greater than 800 K.
B) spontaneous forward at temperatures greater than 800 K.
C) spontaneous reverse only at temperatures greater than 600 K.
D) spontaneous forward at all temperatures.
E) spontaneous reverse at all temperatures.

Answer B

$\Delta H < 0$ => spontaneous reverse at low T.

$\Delta S < 0$ => spontaneous forward at high T.

Crossover Temperature = $\Delta H/\Delta S$ = 40/0.050 = 800 K. Spontaneous reverse at T>800K

31. Consider the freezing of liquid water at –10°C and 1 atm. For this process what are the signs for ΔH, ΔS, and ΔG?

	ΔH	ΔS	ΔG
A)	–	–	–
B)	–	+	0
C)	–	+	–
D)	+	–	–
E)	+	–	0

Answer: A

The process is spontaneous; $\Delta G < 0$, exothermic; $\Delta H < 0$, and is changes directions at high temperature; $\Delta S<0$

32. $\Delta G = \Delta G° + RT\ln(Q)$

When $\Delta G=0$,
A) $Q > K$
B) $Q < K$
C) $\Delta G° < 0$
D) $\Delta G° > 0$
E) the system is at equilibrium.
Answer: E

33. Consider a solution consisting of two acids in water:

$$H_2CO_3 \rightleftharpoons HCO_3^- + H^+ \qquad pK_a = 6.4$$
$$H_2PO_4^- \rightleftharpoons HPO_4^{2-} + H^+ \qquad pK_a = 7.2$$

At pH 6.4, which one of the following is true?
A) $[H_2CO_3] > [HCO_3^-]$ and $[H_2PO_4^-] > [HPO_4^{2-}]$
B) $[H_2CO_3] = [HCO_3^-]$ and $[H_2PO_4^-] > [HPO_4^{2-}]$
C) $[H_2CO_3] = [HCO_3^-]$ and $[H_2PO_4^-] < [HPO_4^{2-}]$
D) $[H_2CO_3] > [HCO_3^-]$ and $[H_2PO_4^-] = [HPO_4^{2-}]$
E) $[H_2CO_3] < [HCO_3^-]$ and $[H_2PO_4^-] = [HPO_4^{2-}]$
Answer: B

34. If 2.0×10^8 L of hydrogen (H_2) at 1.0 atm and 0 °C is combined with excess oxygen and ignited, how much energy will be evolved?

$$H_2(g) + (1/2)O_2(g) \rightarrow H_2O(l) \qquad \Delta H° = -286 \text{ kJ}$$

A) 8.2×10^6 kJ
B) 2.6×10^9 kJ
C) 2.9×10^4 kJ
D) 3.5×10^{11} kJ
E) 5.7×10^{10} kJ
Answer: B
(-286) $2x10^8/22.4 = 25.5 \times 10^8$ kJ

35. 100 ml of 0.1 M HCl and 100 ml of 0.1 M CH_3COOH are each titrated with 0.1 M NaOH. Which of the following would be equal for the two titrations?
A) the initial pH
B) the initial $[H^+]$
C) the volume of NaOH added to reach equivalence point
D) the buffering capacity at the pKa of CH_3COOH
E) none of the above
Answer: C

[*use this information to answer the next two questions*] 1.22 moles of perfect monatomic gas is very slowly expanded from 20 L to 30 L at a constant pressure of 5.0 atm (R = 0.082 L-atm/mol-K; R = 8.31 J/mol-K; 101 J/L-atm).

36. The heat q for this process is
A) 9.8 kJ
B) –9.8 kJ
C) 271 kJ
D) -12.7 kJ
E) 12.7 kJ

Answer: E

$T_i = PV/nR=(5.0\ atm)(30\ L)/(0.082\ L\text{-}atm/mol\text{-}K)(1.22\ mol) = 1500\ K$
$T_f = PV/nR=(5.0\ atm)(15\ L)/(0.082\ L\text{-}atm/mol\text{-}K)(0.171\ mol) = 1000\ K$
$q=nC_p\Delta T = n(5R/2)\Delta T = (1.22\ mol)(5/2)(0.082\ L\text{-}atm/mol\text{-}K)(1000K\text{-}1500K) = -125\ L\text{-}atm$
$(-125\ L\text{-}atm)(101\ J/L\text{-}atm) = 12700\ J = 12.7\ kJ$

37. The work w for this process is
A) –5.05 kJ
B) +5.05 kJ
C) 13.5 kJ
D) –13.5 kJ
E) 27.1 kJ

Answer: A
$w=-P\Delta V = -5(30-20)= -50\ L\ atm$
$(+50\ L\text{-}atm)(101\ J/L\text{-}atm) = -5.05\ kJ$

38. In a solution prepared by adding excess $MgF_2(s)$ [$K_{sp} = 1.08 \times 10^{-10}$] to water, $[Mg^{2+}]$ at equilibrium is:
A) 1.5×10^{-4} mol/L
B) 3.0×10^{-4} mol/L
C) 1.2×10^{-4} mol/L
D) 2.4×10^{-4} mol/L
E) 8.4×10^{-6} mol/L

Answer B
$MgF_2 = Mg^{2+} + 2F^-$ $\quad 2[Mg^{2+}] = [F^-]$
$K_{sp} = [Mg^{2+}][F^-]^2 = [Mg^{2+}](2[Mg^{2+}])^2 = =4([Mg^{2+}])^3 = 1.08 \times 10^{-10}$

Initially, a warm brick (the system) is placed in a cold pool of water (the surroundings). Finally, the system and surroundings reach thermal equilibrium. For this process:

39. A) $\Delta S_{system} > 0$ and $\Delta S_{surroundings} < 0$
B) $\Delta S_{system} = 0$ and $\Delta S_{surroundings} < 0$
C) $\Delta S_{system} > 0$ and $\Delta S_{surroundings} > 0$
D) $\Delta S_{system} < 0$ and $\Delta S_{surroundings} > 0$
E) $\Delta S_{system} < 0$ and $\Delta S_{surroundings} < 0$

40. A) $\Delta S_{universe} > 0$ and $\Delta E_{universe} = 0$
B) $\Delta S_{universe} > 0$ and $\Delta E_{universe} < 0$
C) $\Delta S_{universe} < 0$ and $\Delta E_{universe} = 0$
D) $\Delta S_{universe} < 0$ and $\Delta E_{universe} > 0$
E) $\Delta S_{universe} = 0$ and $\Delta E_{universe} = 0$

41. A 140 g sample of water at 25.0°C is mixed with 100 g of a solid metal at 100°C. After thermal equilibrium is established, the (final) temperature of the water and metal are both 29.6°C. What is the heat capacity of the metal, assuming it is constant?
The specific heat capacity, c_s, for water is 4.184 J/g °C.
A) 0.031 J/g °C
B) 0.76 J/g °C
C) 0.96 J/g °C
D) 0.38 J/g °C
E) 0.64 J/g °C
Answer: D

42. A 100 mL solution contains 1.0 M HNO_2 and 0.70 M $NaNO_2$. 10 mL of 1.5 M HCl is added. The K_a for HNO_2 is 7.2×10^{-4}. Calculate the final pH.
A) 2.8
B) 3.5
C) 1.9
D) 3.1
E) 0.2
Answer A

	$NaNO_2$ + HCl →	HNO_2	
I	0.070	0.015	0.100
C	-0.015	-0.015	+0.015
E	0.055	+0.000	0.115

pH = pKa + log(Base/Acid) = 3.14 + log (0.055/0.115) = 2.8

Section 4 (questions 43-56)

43. The following data were obtained for the reaction of NO with O_2. Concentrations are in M and rates are in M s^{-1}.

$[NO]_0$	$[O_2]_0$	Initial Rate
1×10^{18}	1×10^{18}	2.0×10^{16}
2×10^{18}	1×10^{18}	8.0×10^{16}
3×10^{18}	1×10^{18}	18.0×10^{16}
1×10^{18}	2×10^{18}	4.0×10^{16}
1×10^{18}	3×10^{18}	6.0×10^{16}

Which of the following is the rate law for this reaction?

A) Rate = $k[NO][O_2]$
B) Rate = $k[NO]^2[O_2]$
C) Rate = $k[NO][O_2]^2$
D) Rate = $k[NO]^2$
E) Rate = $k[NO]^2[O_2]^2$

Answer: B

44. Identify your version (look at the top of the page).

A) Version A
B) Version B
C) Version C
D) Version D

45. In the reaction coordinate graph

A) *1* is $\Delta G°_{reaction}$, *2* is $\Delta G°‡_{forward\ first\ step}$, *4* is $\Delta G°‡_{forward\ second\ step}$
B) *1* is $\Delta G°_{reaction}$, *2* is $\Delta G°‡_{forward\ first\ step}$, *7* is $\Delta G°‡_{forward\ second\ step}$
C) *1* is $\Delta G°_{reaction}$, *3* is $\Delta G°‡_{forward\ first\ step}$, *4* is $\Delta G°‡_{forward\ second\ step}$
D) *6* is $\Delta G°_{reaction}$, *2* is $\Delta G°‡_{forward\ first\ step}$, *4* is $\Delta G°‡_{forward\ second\ step}$
E) *6* is $\Delta G°_{reaction}$, *1* is $\Delta G°‡_{forward\ first\ step}$, *5* is $\Delta G°‡_{forward\ second\ step}$

Answer A:

46. From the reaction coordinate graph

A) $k_{forward\ second\ step} > k_{forward\ first\ step} > k_{reverse\ first\ step}$
B) $k_{forward\ first\ step} > k_{forward\ second\ step} > k_{reverse\ second\ step}$
C) $k_{reverse\ second\ step} > k_{forward\ first\ step} > k_{forward\ second\ step}$
D) $k_{forward\ first\ step} > k_{forward\ second\ step} > k_{reverse\ first\ step}$
E) Cannot be determined

Answer A: k forward second step is greater than all other k because the $\Delta G°‡$ for that step is smallest.

47. The reaction $2H_2O_2 \rightarrow 2H_2O + O_2$ has the following mechanism.

$$H_2O_2 + I^- \rightarrow H_2O + IO^-$$
$$H_2O + IO^- \rightarrow H_2O + O_2 + I^-$$

The catalyst in the reaction is:

A) H_2O
B) O_2
C) H_2O_2
D) IO^-
E) I^-

Answer: E

48. A first-order reaction is 42% complete at 17 minutes. Assuming negligible reverse reaction, what is the rate constant?

A) 3.2×10^{-2} min^{-1}
B) 20 min^{-1}
C) 31 min^{-1}
D) 0.11 min^{-1}
E) 5.1×10^{-2} min^{-1}

Answer: E
$[A]_t = [A]_o e^{-kt}$
$k = -\ln[(0.42)](17 \text{ min}) = 0.051 \text{ min}^{-1}$

49. Determine the equilibrium constant at 25°C for the reaction

$$Zn + Ni^{2+} \rightarrow Zn^{2+} + Ni$$
$$Zn^{2+} + 2e^- \rightarrow Zn \qquad E° = -0.76 \text{ V}$$
$$Ni^{-2+} + 2e^- \rightarrow Ni \qquad E° = -0.23 \text{ V}$$

A) 8.6×10^{17}
B) 9.3×10^{8}
C) 4.1×10^{3}
D) 6.4×10^{-6}
E) none of these

Answer: A
$E°_{cell} = -0.23+0.76=+0.53$ V
$\Delta G° = -nFE° = -2(96{,}485 \text{ J/V})(0.53\text{V}) = -102{,}274$ J/mol
$\Delta G° = -RT\ln K$: $K = \exp(-\Delta G°/RT) = \exp(+102{,}274 \text{ J/mol})/[298\text{K}(8.31 \text{ J/mol-K})]$
$= 8.6 \times 10^{17}$

50. Consider an electrochemical cell with a copper (Cu^{2+}) electrode immersed in $Cu^{2+}(aq)$ and a silver (Ag^+) electrode immersed in $Ag^+(aq)$.

$Cu^{2+} + 2e^- \rightarrow Cu \qquad E° = 0.34$ V
$Ag^+ + e^- \rightarrow Ag \qquad E° = 0.80$ V

If $[Cu^{2+}]$ is 0.0010 M and $[Ag^+]$ is 0.10 M, calculate *E*.

A) 0.33 V
B) 0.40 V
C) 0.43 V
D) 0.49 V
E) 0.52 V
*Answer: C
$Cu + 2Ag^+ \rightarrow Cu^{2+} + 2Ag$ $E°cell = 0.80 - 0.34 = 0.46$ V
$E = E°cell - (0.05916/n) \log [Cu^{2+}]/[Ag^+]^2$
$E = 0.46 - (0.05916/2) \log (0.001/0.01) = 0.46 \text{ V} - 0.03 \text{ V} = 0.43$ V.

51. For the decomposition of nitrous oxide (N_2O) to N_2 and O_2:
Rate = $k[N_2O]^2$. Several mechanisms are proposed:

A. $N_2O \rightarrow N_2 + O$ $N_2O + O \rightarrow N_2 + O_2$	*B.* $N_2O \rightarrow N + NO$ $N_2O + N + NO \rightarrow N_3 + O_2$ $2N_3 \rightarrow 3N_2$
C. $2N_2O \rightarrow N_4O_2$ $N_4O_2 \rightarrow 2N_2 + O_2$	*D.* $3N_2O \rightarrow N_6O_3$ $2N_6O_3 \rightarrow 6N_2 + 3O_2$

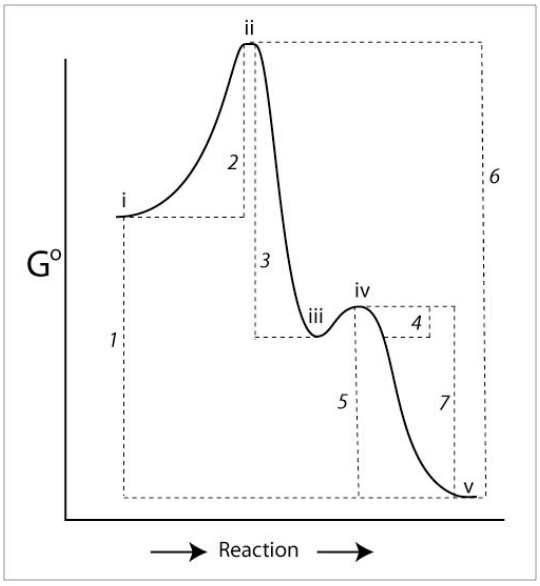
Which of the mechanisms above is most likely to be correct?
A) Mechanism A.
B) Mechanism B.
C) Mechanism C.
D) Mechanism D.
E) None of these mechanisms are consistent with the experimental rate law.
Answer: C

52. The rate of a reaction can change with
A) Temperature.
B) The addition of a catalyst or enzyme.
C) Reactant concentrations.
D) Time
E) All (A-D)
Answer: E

53. The rate of disappearance of ozone in the reaction $2O_3(g) \rightarrow 3O_2(g)$ is 9.0×10^{-3} atm s^{-1}. What is the rate of appearance of O_2?
A) 9.0×10^{-3} atm s^{-1}
B) 1.3×10^{-2} atm s^{-1}
C) 6.0×10^{-3} atm s^{-1}
D) 3.0×10^{-5} atm s^{-1}
E) 2.7×10^{-5} atm s^{-1}
Answer: B

$(3/2)9.0 \times 10^{-3} = 1.3 \times 10^{-2}$ atm/s

54. Which is correct (see graph)



A) i is the reactant, iii is a transition state, v is the product.
B) v is the reactant, iv is the first transition state, iii is an intermediate, ii is the second transition state, i is the product.
C) iii is the reactant, ii is the one transition state, iv is another transition state, i and v are products.
D) i is the reactant, ii is the first intermediate, iii is the second intermediate, iv is the third intermediate, v is the product.
E) i is the reactant, ii is the first transition state, iii is the intermediate, iv is the second transition state, v is the product.

Answer: E

55. A moderately spontaneous reaction, with a small forward driving force
A) is necessarily a slow forward reaction.
B) is necessarily a fast forward reaction.
C) is necessarily a slow reverse reaction.
D) is necessarily a fast reverse reaction.
E) None of these are correct
Answer: E. Don't confuse kinetics and thermodynamics. The rate constant is determined by the activation energy, which might be large or small for a spontaneous reaction.

56. From the reaction coordinate graph above
A) K > 1B) K < 1
C) K = 1

D) K < -1
E) K > -1
Answer: A

Section 5 (questions 57-61)

Use the following laboratory information from the Excel table to answer question 57-59.

In lab experiment 8, Determination of K_{eq} , the equilibrium constant for the formation of iron thiocyanate was calculated by measuring the absorbance of the orange colored product formed after mixing solutions of iron(III) ions and thiocyanate ions as:

$$Fe^{3+}(aq) + SCN^{-}(aq) \rightarrow [Fe(SCN)]^{2+}(aq)$$

Test tubes 1-5 were used to construct a Beer's Law plot, A = εbC, for use in calculating K_{eq} from test tubes 6-12.

	A	B	C	D	E	F	G	H	I
1	**Useful Units**								
2	Test Tube 1-5 $[Fe(NO_3)_3]_{Stock}$ =		0.0025	Test Tube 1-5 $[SCN^-]_{Stock}$ =		0.5	Test Tube 6-12 $[SCN^-]_{Stock}$ =	0.0025	
3	**Tabulated Data/Results**								
4	Test Tube	**Working** Fe^{3+} (ml)	Stock SCN^- (ml)	0.1 M HNO_3 (ml)	Total (ml)	$[Fe^{3+}]_{initial}$ (M)	$[SCN^-]_{initial}$ (M)	Absorbance	$[Fe(SCN)^{2+}]$
5									
6	1	1.0	5.0	4.0				0.100	
7	2	2.0	5.0	3.0				0.200	
8	3	3.0	5.0	2.0				0.250	
9	4	4.0	5.0	1.0				0.320	
10	5	5.0	5.0	0				0.420	
11									
12									
13	Test Tube	**Stock** Fe^{3+} (ml)	Stock SCN^- (ml)	0.1 M HNO_3 (ml)	Total (ml)	$[Fe^{3+}]_{initial}$ (M)	$[SCN^-]_{initial}$ (M)	Absorbance	$[Fe(SCN)^{2+}]$
14	6	1.0	1.5	4.5		3.57E-04	3.57E-04	0.120	2.2E-05
15	7	1.0	2.0	4.0		3.57E-04	5.36E-04	0.198	3.3E-05
16	8	1.0	2.5	3.5		3.57E-04	7.14E-04	0.268	4.0E-05
17	9	1.0	3.0	3.0		3.57E-04	8.93E-04	0.324	4.4E-05
18	10	2.0	1.0	4.0		3.57E-04	1.07E-03	0.351	3.0E-05
19	11	2.0	1.5	3.5		7.14E-04	3.57E-04	0.243	4.1E-05
20	12	2.0	2.0	3.0		7.14E-04	5.36E-04	0.330	5.7E-05
21									

57. Write an excel format equation using the cell locations that would be entered to determine the final $[Fe^{3+}]$ from test tube 6 after equilibrium was established. (i.e. Excel Equation $[Fe^{3+}]_{final}$ =A2*B2/2)

A) $[Fe^{3+}]_{final}$ = (I14*H2)/7
B) $[Fe^{3+}]_{final}$ = H14/F14
C) $[Fe^{3+}]_{final}$ = F14-I14

D) $[Fe^{3+}]_{final}$ = (I14-F6)/7 E) $[Fe^{3+}]_{final}$ = G14-I14

Answer: C

58. How did you know the concentration of the product, $[Fe(SCN)]^{2+}(aq)$ in test tubes 1-5?

A) I assumed that $[Fe(SCN)]^{2+} = [SCN^-]_{initial}$
B) I assumed that $[Fe(SCN)]^{2+} = [Fe^{3+}]_{initial}$
C) I read it off the Absorbance vs. Concentration plot
D) Options A and B
E) None of these
Answer: B

59. A working solution was made in a 100 mL volumetric flask by diluting 4.0 mL of iron stock solution to 100 mL to use in test tubes 1-5. Then the working solution was diluted according to the table. What is the initial concentration of iron in cell F7?

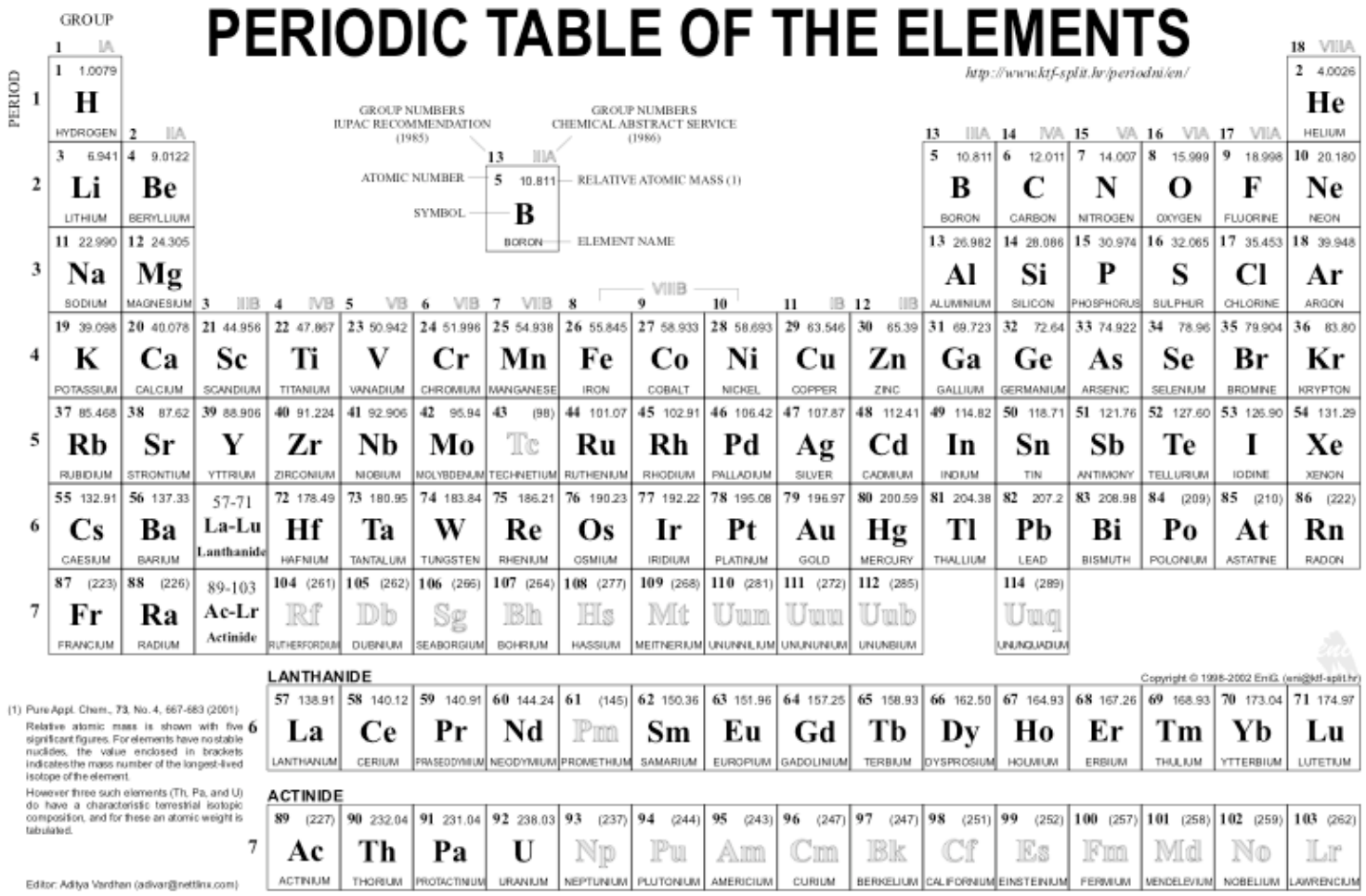
A) 0.50 M
B) 0.0025 M
C) 0.0005 M
D) 0.00002 M
E) 0.0001 M
Answer: D

60. In Experiment 10, Applications of Equilibria, you found that your unknown "blood" sample was 0.10 M in acetic acid from the titration analysis (curve). How much 6M NaOH would have to be added to a 100.0 mL sample to make a buffered blood sample with equal moles of HA and A^- (pH 4.74, assume the volume of NaOH added to be neglible)

A) 100.0 mL
B) 0.83 mL
C) 1.7 mL
D) 2.4 mL
E) I need the K_a to figure this out
Answer: B

61. In Experiment 11, Calorimetry, Heats of Reactions and Hess's Law, you made a coffee cup calorimeter and calibrated it before using it to measure heats of reactions. Why did the calorimeter need to be calibrated with hot and cold water?

A) The calorimeter needed to be heated up to the maximum temperature of the reaction
B) The calorimeter absorbed heat and cold unequally
C) The calorimeter was a perfect insulator
D) All of the heat generated in the reaction was not transferred to the water and thermometer for measurement
Answer: D


PERIODIC TABLE OF THE ELEMENTS
http://www.ktf-split.hr/periodni/en/
GROUP
PERIOD
GROUP NUMBERS IUPAC RECOMMENDATION (1985)
GROUP NUMBERS CHEMICAL ABSTRACT SERVICE (1986)
ATOMIC NUMBER
SYMBOL
RELATIVE ATOMIC MASS (1)
ELEMENT NAME
HYDROGEN
HELIUM
LITHIUM
BERYLLIUM
BORON
CARBON
NITROGEN
OXYGEN
FLUORINE
NEON
SODIUM
MAGNESIUM
ALUMINIUM
SILICON
PHOSPHORUS
SULPHUR
CHLORINE
ARGON
POTASSIUM
CALCIUM
SCANDIUM
TITANIUM
VANADIUM
CHROMIUM
MANGANESE
IRON
COBALT
NICKEL
COPPER
ZINC
GALLIUM
GERMANIUM
ARSENIC
SELENIUM
BROMINE
KRYPTON
RUBIDIUM
STRONTIUM
YTTRIUM
ZIRCONIUM
NIOBIUM
MOLYBDENUM
TECHNETIUM
RUTHENIUM
RHODIUM
PALLADIUM
SILVER
CADMIUM
INDIUM
TIN
ANTIMONY
TELLURIUM
IODINE
XENON
CAESIUM
BARIUM
57-71 La-Lu Lanthanide
HAFNIUM
TANTALUM
TUNGSTEN
RHENIUM
OSMIUM
IRIDIUM
PLATINUM
GOLD
MERCURY
THALLIUM
LEAD
BISMUTH
POLONIUM
ASTATINE
RADON
FRANCIUM
RADIUM
89-103 Ac-Lr Actinide
RUTHERFORDIUM
DUBNIUM
SEABORGIUM
BOHRIUM
HASSIUM
MEITNERIUM
UNUNNILIUM
UNUNUNIUM
UNUNBIUM
UNUNQUADIUM
LANTHANIDE
LANTHANUM
CERIUM
PRASEODYMIUM
NEODYMIUM
PROMETHIUM
SAMARIUM
EUROPIUM
GADOLINIUM
TERBIUM
DYSPROSIUM
HOLMIUM
ERBIUM
THULIUM
YTTERBIUM
LUTETIUM
ACTINIDE
ACTINIUM
THORIUM
PROTACTINIUM
URANIUM
NEPTUNIUM
PLUTONIUM
AMERICIUM
CURIUM
BERKELIUM
CALIFORNIUM
EINSTEINIUM
FERMIUM
MENDELEVIUM
NOBELIUM
LAWRENCIUM
(1) Pure Appl. Chem., 73, No. 4, 667-683 (2001)
Relative atomic mass is shown with five significant figures. For elements have no stable nuclides, the value enclosed in brackets indicates the mass number of the longest-lived isotope of the element.
However three such elements (Th, Pa, and U) do have a characteristic terrestrial isotopic composition, and for these an atomic weight is tabulated.
Editor: Aditya Vardhan (adivar@netlinx.com)
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Physical Constants

Physical Constants

Constant	Symbol	Value
Atomic Mass Unit	amu	1.66054×10^{-27} kg
Avogadro's Number	N	6.022×10^{23} mol^{-1}
Bohr Radius	a_o	5.292×10^{-11} m
Boltzmann's constant	k	1.38066×10^{-23} J/K
Charge of an electron	e	1.60218×10^{-19} C
Gas Constant	R	8.314 J K^{-1} mol^{-1}
		0.08206 L atm K^{-1} mol^{-1}
Mass of an Electron	m_e	9.10939×10^{-31} kg
Mass of a Neutron	m_n	1.67493×10^{-27} kg
Mass of a Proton	m_p	1.67262×10^{-27} kg
Planck's constant	h	6.62608×10^{-34} J s
Speed of Light	c	2.998×10^{8} m s^{-1}
Specific Heat of Water		4.184 J/gC