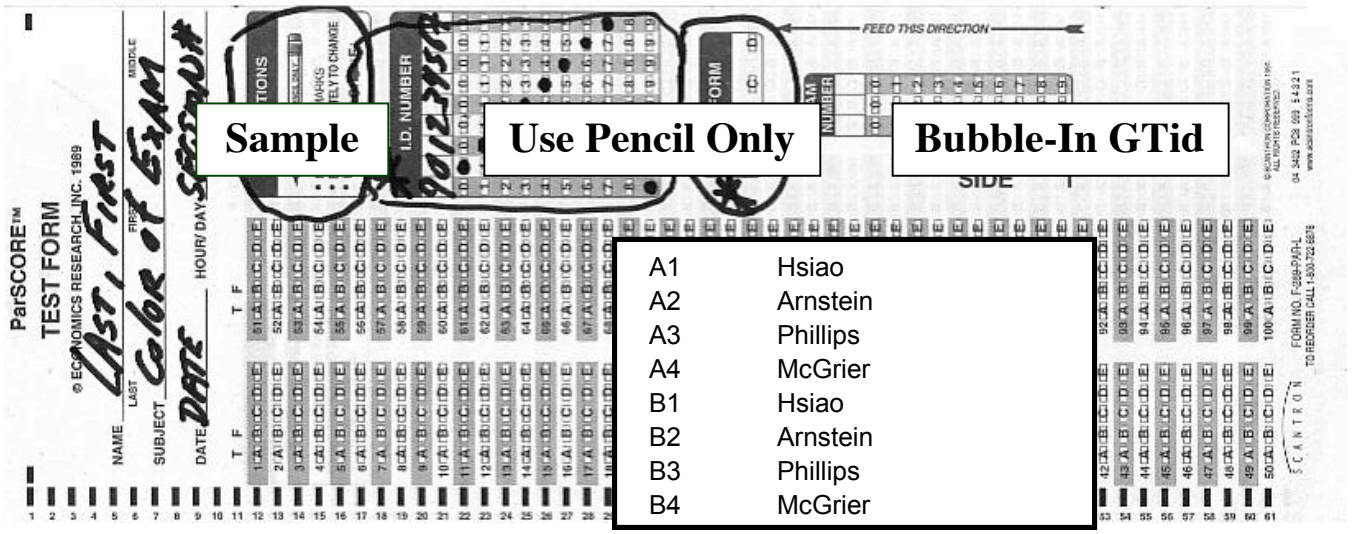
Chem. 1310 Fall 2005 Final Exam-white December 15, 2005 Professor Williams

Name _____ Section Number _____

***Please read the following before proceeding***

1. On the Scantron card, you must **bubble-in your GTid number**. In the space provided, write your **Name**. Write the ***Color*** of your exam in the Subject section and bubble-in the letter for the **Test Form (White=A, Green=B, Yellow=C)**. Write your **section number** in the Hour/Date section. See sample below.
2. This exam is divided into four sections. Each of which will be graded independently.
3. Materials: Turn off cell phones and wireless PDA devices. Clear all papers and books from your desk. You will need a pencil, a calculator and a Scantron answer form.
4. This exam is multiple-choice. It is highly recommended that you record your work on the actual exam (this document). There is no partial credit.
5. Show your Buzz Card when you turn in your completed exam and Scantron card.
6. You must work alone. Give or take no assistance from other students. Recall the Georgia Tech Honor Code. "I pledge my honor that I have not violated the Honor Code during this examination."

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Units, equations, etc.

1 ml = 1 cc = 1 $cm^3$ 1 L-atm= 101 J

1 meter = 100 cm = $10^9$ nanometers = $10^{10}$ Ångstroms

R = gas constant = 0.082 L-atm/K-mole = 8.31 J/K-mole

$PV=nRT$ $w=-P_{ext}\Delta V$ $q_p=\Delta H$

$\Delta E= q+w$ $\Delta E_{universe} = 0$ $\Delta G° = \Delta H°-T\Delta S°$ $\Delta S°_{vap}=\Delta H°_{vap}/T_b$

$\Delta S_{uni} = \Delta S_{sys}+\Delta S_{sur}$ $w_{elec}=-Q\Delta\varepsilon = It\Delta\varepsilon$ $\Delta G°_r = -nF\Delta\varepsilon°$ F=96,458 C $mol^{-1}$

$\Delta\varepsilon° = \varepsilon°(\text{cathode}) - \varepsilon°(\text{anode})$

$$\Delta\varepsilon = \Delta\varepsilon° - \frac{RT}{nF}\ln Q \quad \Delta\varepsilon° = \frac{RT}{nF}\ln K \quad \Delta G = \Delta G° + RT\ln Q \quad \Delta G° = -RT\ln K$$

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# PERIODIC TABLE OF THE ELEMENTS

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 H 1.008 | | | | | | | | | | | | | | | | | 2 He 4.003 |
| 3 Li 6.941 | 4 Be 9.012 | | | | | | | | | | | 5 B 10.811 | 6 C 12.011 | 7 N 14.007 | 8 O 15.999 | 9 F 18.999 | 10 Ne 20.180 |
| 11 Na 22.989 | 12 Mg 24.305 | | | | | | | | | | | 13 Al 26.982 | 14 Si 28.0856 | 15 P 30.974 | 16 S 32.066 | 17 Cl 35.453 | 18 Ar 39.948 |
| 19 K 39.098 | 20 Ca 40.078 | 21 Sc 44.955 | 22 Ti 47.867 | 23 V 50.941 | 24 Cr 51.996 | 25 Mn 54.938 | 26 Fe 55.845 | 27 Co 58.933 | 28 Ni 58.693 | 29 Cu 63.546 | 30 Zn 65.39 | 31 Ga 69.723 | 32 Ge 72.61 | 33 As 74.922 | 34 Se 78.96 | 35 Br 79.904 | 36 Kr 83.80 |
| 37 Rb 85.467 | 38 Sr 87.62 | 39 Y 88.905 | 40 Zr 91.224 | 41 Nb 92.906 | 42 Mo 95.94 | 43 Tc 98 | 44 Ru 101.07 | 45 Rh 102.905 | 46 Pd 106.42 | 47 Ag 107.868 | 48 Cd 112.411 | 49 In 114.818 | 50 Sn 118.710 | 51 Sb 121.760 | 52 Te 127.60 | 53 I 126.904 | 54 Xe 131.29 |
| 55 Cs 132.905 | 56 Ba 137.327 | 57 to 71 | 72 Hf 178.49 | 73 Ta 180.947 | 74 W 183.84 | 75 Re 186.207 | 76 Os 190.23 | 77 Ir 192.217 | 78 Pt 195.078 | 79 Au 196.967 | 80 Hg 200.59 | 81 Tl 204.383 | 82 Pb 207.2 | 83 Bi 208.980 | 84 Po 209 | 85 At 210 | 86 Rn 222 |
| 87 Fr 223 | 88 Ra 226 | 89 to 103 | 104 Rf 261 | 105 Db 262 | 106 Sg 263 | 107 Bh 264 | 108 Hs 265 | 109 Mt 268 | 110 Uun 269 | 111 Uuu 272 | 112 Uub 277 | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 57 La 138.906 | 58 Ce 140.116 | 59 Pr 140.908 | 60 Nd 144.24 | 61 Pm 145 | 62 Sm 150.36 | 63 Eu 151.964 | 64 Gd 157.25 | 65 Tb 158.925 | 66 Dy 162.50 | 67 Ho 164.930 | 68 Er 167.26 | 69 Tm 168.934 | 70 Yb 173.04 | 71 Lu 174.967 |
| 89 Ac 227 | 90 Th 232.038 | 91 Pa 231.036 | 92 U 238.029 | 93 Np 237 | 94 Pu 244 | 95 Am 243 | 96 Cm 247 | 97 Bk 247 | 98 Cf 251 | 99 Es 252 | 100 Fm 257 | 101 Md 258 | 102 No 259 | 103 Lr 262 |

**Table 4–1**
**Solubilities of Ionic Compounds in Water**

| Anion | Soluble[a] | Slightly Soluble | Insoluble |
|---|---|---|---|
| $NO_3^-$ (nitrate) | All | — | — |
| $CH_3COO^-$ (acetate) | Most | — | $Be(CH_3COO)_2$ |
| $ClO_3^-$ (chlorate) | All | — | — |
| $ClO_4^-$ (perchlorate) | Most | $KClO_4$ | — |
| $F^-$ (fluoride) | Group I,[b] AgF, $BeF_2$ | $SrF_2$, $BaF_2$, $PbF_2$ | $MgF_2$, $CaF_2$ |
| $Cl^-$ (chloride) | Most | $PbCl_2$ | AgCl, $Hg_2Cl_2$ |
| $Br^-$ (bromide) | Most | $PbBr_2$, $HgBr_2$ | AgBr, $Hg_2Br_2$ |
| $I^-$ (iodide) | Most | — | AgI, $Hg_2I_2$, $PbI_2$, $HgI_2$ |
| $SO_4^{2-}$ (sulfate) | Most | $CaSO_4$, $Ag_2SO_4$, $Hg_2SO_4$ | $SrSO_4$, $BaSO_4$, $PbSO_4$ |
| $S^{2-}$ (sulfide) | Groups I and II,[c] $(NH_4)_2S$ | — | Most |
| $CO_3^{2-}$ (carbonate) | Group I, $(NH_4)_2CO_3$ | — | Most |
| $SO_3^{2-}$ (sulfite) | Group I, $(NH_4)_2SO_3$ | — | Most |
| $PO_4^{3-}$ (phosphate) | Group I, $(NH_4)_3PO_4$ | $Li_3PO_4$ | Most |
| $OH^-$ (hydroxide) | Group I, $Ba(OH)_2$ | $Sr(OH)_2$, $Ca(OH)_2$ | Most |

[a]Soluble compounds are defined as those that dissolve to the extent of 1 g or more per 100 g water, slightly soluble as 0.01 to 1 g per 100 g water, and insoluble as less than 0.01 g per 100 g water at room temperature.
[b]Compounds of elements from the first column in the periodic table: Li, Na, K, Rb, Cs.
[c]Compounds of elements from the second column in the periodic table: Be, Mg, Ca, Sr, Ba.

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## Final Exam Section 1 (questions 1-20)

1. Under conditions of fixed temperature and amount of gas, Boyle's law requires that
a. $P_1V_1 = P_2V_2$
b. $P^2V^2$ = constant
c. $P_1/P_2 = V_1/V_2$
d. all of these
e. none of these
Answer: a:
comment: b is also correct. This question scored correct regardless of answer.

2. A pure sample of an iron oxide weighing 30 g is heated in a stream of $H_2(g)$ until it is completely converted to pure iron. If the iron produced has a mass of 20 g, the percentage by mass of oxygen in the original oxide must have been
a. 86%
b. 67%
c. 33%
d. 14%
e. none of these
Answer: c

3. Analysis of a sample of magnesium oxide shows that it contains 4.6 g of magnesium and 3.0 g of oxygen. If a second sample of the same oxide contains 13.8 g of magnesium, how much oxygen does it contain?
a. 0.90 g
b. 1.01 g
c. 9.0 g
d. 10.2 g
e. none of these
Answer: c

4. An unknown mass of element A reacts completely with 1.8 g of element B and 3.6 g of element C to produce 7.1 g of a compound containing A, B, and C. What additional information is required in order to calculate the unknown mass of A?
a. a balanced equation for the reaction
b. the molar masses of A, B
c. the molar mass of C
d. all of the above are required
e. none of the above is required
Answer: e

5. The ratio of the number of bismuth atoms to the number of oxygen atoms in $Bi_2(SO_4)_3$ is
a. 1:6
b. 2:7
c. 2:3
d. 2:1
e. none of these
Answer: a

6. A chemist requires 0.01 mol of some liquid for a reaction. If the density of the liquid is 2 g $cm^{-3}$, and the molecular weight is 100 g $mol^{-1}$, what volume of the liquid should she use for the reaction?
a. 0.5 $cm^3$
b. 0.05 $cm^3$
c. 1.0 $cm^3$
d. 10 $cm^3$

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e. none of these

Answer: a

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7. Consider the unbalanced chemical equation,

$$Al(OH)_3 + H_2CO_3 \rightarrow Al_2(CO_3)_3 + H_2O.$$

When the reaction is balanced with smallest integer stoichiometric coefficients, the coefficient for $H_2CO_3$ is

a. 1
b. 2
c. 3
d. 5
e. none of these
Answer: c

8. Zinc sulfide (ZnS) reacts with oxygen to form zinc oxide (ZnO) and gaseous sulfur dioxide ($SO_2$). What mass of $SO_2$ is produced by the complete conversion of 9.7 g of ZnS to ZnO?
a. 3.3 g
b. 5.0 g
c. 8.5 g
d. 10 g
e. none of these
Answer: e

9. When aqueous solutions of $MgCl_2$ and NaOH are mixed, a salt precipitates, in accord with the reaction (unbalanced),

$$MgCl_2(aq) + NaOH(aq) \rightarrow Mg(OH)_2(?) + NaCl(?)$$

The (?) indicates unknown phase (s, l, aq or g). How much salt precipitates when 100 mL of a 0.30 M solution of $MgCl_2$ is mixed with 100 mL of 0.20 M NaOH?
a. 0.50 g
b. 0.58 g
c. 1.74 g
d. 1.2 g
e. none of these
Answer: b

10. In comparison with core electrons the valence electrons of an atom determine most of its chemistry, because the valence electrons are
a. more negatively charged due to their distance from the center.
b. more shielded from the effects of approaching atoms.
c. more strongly affected when other atoms approach.
d. All of these are correct.
e. None of these is correct.
Answer: c

11. The positive charge on the nucleus of a neutral atom is equal in magnitude to the
a. atomic mass.
b. total charge of the electrons in the atom.
c. mass number.
d. all of these.
e. none of these.
Answer: b

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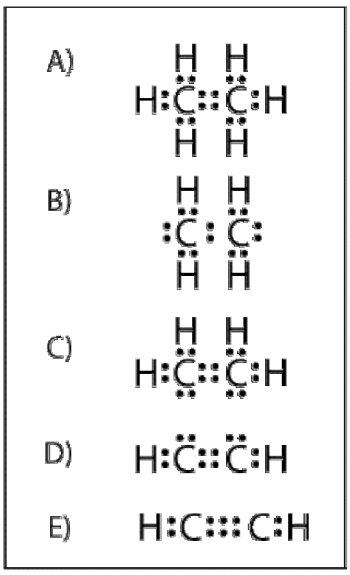
12. In which of the following atoms is the number of valence electrons equal to five?
a. C
b. N
c. O
d. F
e. Ne
Answer: b

13. Which of these Lewis dot structures is correct?




a. Structure A
b. Structure B
c. Structure C
d. Structure D
e. Structure E
Answer: e

14. The oxidation number of the bromine atom in $Ca(BrO_3)_2$ is
a. –1
b. +1
c. +3
d. +5
e. none of these
Answer: d

15. If a solution containing 4.0 g of NaOH is exactly neutralized by 100 mL of an aqueous HCl solution, the molarity of the HCl solution must have been
a. 0.010 M
b. 0.10 M
c. 1.0 M
d. 10 M
e. none of these
Answer: c

16. There are how many 3p orbitals in a given atom?
a. 1

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b. 3
c. 5
d. 10
e. none of these
Answer: b

17. There are how many 4d orbitals in a given atom?
a. 1
b. 3
c. 5
d. 10
e. none of these
Answer: c

18. The element with the electron configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2$ is
a. Sr
b. Be
c. Cl
d. K
e. none of these
Answer: e

19. A single 4s orbital can hold how many electrons?
a. 1
b. 2
c. 6
d. 10
e. none of these
Answer: b

20. An element has two naturally occurring isotopes. The first has an atomic mass of 100 g/mol and an abundance of 65%, while the second has an atomic mass of 90.0 g/mol. The chemical relative atomic mass of the element is therefore
a. 78.9
b. 93.5
c. 96.5
d. 121.
e. none of these
Answer: c
[(0.65*100)+(0.35*90)]= 65+31.5= 96.5]

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## Final Exam Section 2 (questions 21-40)

21. Things that happen spontaneously
a. increase the entropy of the universe.
b. decrease the energy of the universe.
Answer: a

22. Which of the following are generally true?
a. Intermolecular forces are weaker than covalent bonds.
b. Intermolecular forces are more directional than covalent bonds.
c. Any molecule in a gas experiences intermolecular forces.
d. All of these are valid generalizations.
e. None of these are valid generalizations.
Answer: a

23. In a solution of sodium chloride in water, molecular interactions between species arise from
a. ion-ion interactions.
b. ion-dipole interactions.
c. dipole-dipole interactions.
d. dispersive interactions.
e. all are correct.
Answer: e

24. The water vapor pressure of a dilute solution of NaBr(aq) is
a. less than that of a more concentrated NaBr(aq) solution.
b. greater than that of a more concentrated NaBr(aq) solution.
c. equal to that of a more concentrated solution of NaBr(aq).
d. equal to that of the pure NaBr (s).
e. none of these.
Answer: b

25. As the equilibrium state of a chemical reaction is approached,
a. the rate of the forward reaction approaches zero.
b. the rate of the reverse reaction approaches zero.
c. the rates of the forward and backward reactions approach each other.
d. both a & b are correct.
e. none of these.
Answer: c

For the next two questions consider the chemical reaction, at 250°C, at fixed volume.

$PCl_3(g) + Cl_2(g) \iff PCl_5(g)$.

26. The equilibrium partial pressures are $P_{PCl3} = 0.400$ atm, $P_{Cl2} = 0.500$ atm, and $P_{PCl5} = 0.0930$ atm. Therefore the equilibrium constant K for the reaction at 250°C
a. 0.12
b. 0.47
c. 2.2
d. 8.6
e. none of these.
Answer: b

27. If the system is at equilibrium, and Ne(g) is injected it, the partial pressure of $PCl_3$ will
a. increase.
b. decrease.
c. not change.

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d. cannot be predicted
Answer: c

28. The conjugate base of $HPO_4^{2-}$ is

a. $H_3PO_4$

b. $H_2PO_4^-$

c. $PO_4^{3-}$

d. $PO_3^-$

e. none of these.
Answer: c

29. For an aqueous solution at 25°C, if $[H^+] = 0.050$ M, then $[OH^-]$ =
a. $2.0 \times 10^{-12}$ M
b. $1.0 \times 10^{-7}$ M
c. $2.0 \times 10^{-6}$ M
d. $5.0 \times 10^{-2}$ M
e. none of these.
Answer: e

30. What is the pH of a 0.001 M HCl(aq) solution at 25°C?
a. $10^{-3}$
b. $10^{-4}$
c. 4
d. 3
e. None of these.
Answer: d

31. What is the pH of a $2.6 \times 10^{-10}$ M NaOH(aq) solution at 25°C?
a. 2.8
b. 4.4
c. 7.0
d. 10.6
e. None of these.
Answer: c

The next three questions concern the weak base hydroxylamine ($HONH_2$), for which $K_b = 1.1 \times 10^{-8}$ at 25°C.

32. What is the pH of a 0.60 M aqueous hydroxylamine solution at 25°C?
a. 6.9
b. 7.9
c. 8.9
d. 9.9
e. None of these.
Answer: d

33. At which pH would hydroxylamine be the best buffer?
a. 6.0
b. 7.4
c. 8.5
d. 9.9
e. None of these.

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Answer: a

34. At the pH specified in the previous question, what is $-\log_{10}\frac{[HONH_3^+]}{[HONH_2]}$?

a. $10^{-7}$
b. 7
c. 1
d. 0
e. None of these.
Answer: d

35. Which of the following $K_a$ values belongs to the strongest acid?
a. $6.6 \times 10^{-4}$
b. $4.6 \times 10^{-4}$
c. $9.1 \times 10^{-8}$
d. $3.0 \times 10^{-8}$
e. Cannot be determined from the given information.
Answer: a

36. If an acid has Ka = $4.93 \times 10^{-10}$, then Kb for the conjugate base is
a. $5.17 \times 10^{-10}$
b. $9.95 \times 10^{-8}$
c. $2.03 \times 10^{-4}$
d. $5.17 \times 10^{-4}$
e. none of these.
Answer: e

37. For AgCl(*s*), $K_{sp} = 1.6 \times 10^{-10}$. As the pH is lowered, the solubility of AgCl in water will
a. increase.
b. decrease.
c. remain unchanged.
d. This cannot be predicted.
Answer: c

For the next question, consider cadmium hydroxide [$Cd(OH)_2$], for which the solubility in water at 25°C is $1.7 \times 10^{-5}$ M .

38. The solubility product expression for the dissolution of $Cd(OH)_2(s)$ in water is $K_{sp}$ =
a. $[Cd^{2+}][OH^-]^2/[\ Cd(OH)_2]$
b. $[Cd^{2+}][2OH^-]^2$
c. $[Cd^{2+}][2OH^-]$
d. $[Cd^{2+}][OH^-]^2$
e. None of these.
Answer: d

For the next question, consider the following solubility product data for various chromates at 25°C:
$K_{sp}\ Ag_2CrO_4 = 1.9 \times 10^{-12}$
$K_{sp}\ BaCrO_4 = 2.1 \times 10^{-10}$
$K_{sp}\ PbCrO_4 = 1.8 \times 10^{-14}$

39. The chromate that is least soluble in water at 25°C is
a. $Ag_2CrO_4$
b. $BaCrO_4$
c. $PbCrO_4$
d. impossible to determine.

e. all are equivalent.
Answer: c

40. The value of the equilibrium constant for a chemical reaction with two gas phase reactants is dependent upon
a. temperature.
b. initial amounts of reactants present.
c. total pressure.
d. all of these (a-c).
e. none of these (not a-c).
Answer: a

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## Final Exam Section 3 (questions 41-60)

41. The heat gained by a system in a process carried out at constant pressure is
a. w
b. ΔH
c. ΔT
d. ΔE
e. ΔS
Answer: b

42. Which one of the following statements is true concerning the equation below?

$$N_2 + 3H_2 \iff 2NH_3 \qquad \Delta H_r^\circ = -460 \text{ kJ}$$

a. The reaction of 1.0 mole of $H_2$ produces 153 kJ of heat.
b. The reaction of 1.0 mole of $N_2$ consumes 460 kJ of heat.
c. The production of 1.0 mole of $NH_3$ consumes 460 kJ of heat.
d. The complete reaction of 1 mole of $H_2$ requires 3 moles of $N_2$.
e. All of these are true statements.
Answer: a

43. Which of the following is not a state function?
a. q
b. E
c. H
d. G
e. All of these are state functions.
Answer: a

44. The First Law of Thermodynamics states that
a. work and heat are interconvertable.
b. enthalpy is conserved.
c. entropy increases during a spontaneous process.
d. G, H and S are state functions.
e. none of the above.
Answer: a

45. Which of the following processes has ΔH > 0?
a. combustion of a hydrocarbon. (gives off heat, $\Delta H_{comb} < 0$)
b. dilution of concentrated hydrochloric acid with water. (gives off heat, $\Delta H_{dil} < 0$)
c. melting of liquid $H_2O$. (takes in heat, $\Delta H_{melt} > 0$)
d. condensation of liquid $H_2O$. (gives off heat, $\Delta H_{condense} < 0$)
e. none of these have ΔH > 0.
Answer: c
comment: phrase "melting of liquid $H_2O$" confusing, answer e also accepted.

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Given the following enthalpies of formation:

| Species | $\Delta H_f°$ (kJ $mol^{-1}$) |
|---|---|
| glucose [$C_6H_{12}O_6(s)$] | −1274 |
| $CO_2(g)$ | −393 |
| $H_2O(l)$ | −286 |

46. What is the standard enthalpy of combustion of glucose to form carbon dioxide and liquid water.
a. −2800 kJ $mol^{-1}$
b. −1953 kJ $mol^{-1}$
c. −595 kJ $mol^{-1}$
d. 595 kJ $mol^{-1}$
e. none of these
Answer: a

47. In any process, $\Delta E_{univ}$ =
a. $\Delta E_{sys}$
b. $\Delta E_{surr}$
c. $-\Delta E_{sys}$
d. $-\Delta E_{surr}$
e. 0
Answer: e

Information for the next two questions: A gas is compressed from 45 L to 18 L at a constant external pressure of 5.0 atm. During this process 9.8 kJ of energy is released to the surroundings as heat.

48. The heat change q of the system for this process is
a. 135 kJ
b. −135 kJ
c. −9.8 kJ
d. 9.8 kJ
e. 270 kJ
Answer: c

49. The work w done by the system during this process is
a. 135 L atm
b. −135 L atm
c. −9.82 L atm
d. 9.82 L atm
e. 270 kJ
Answer: a

50. For a balloon expanding against atmospheric pressure,
a. the work w done by the balloon is positive.
b. the work w done by the balloon is negative.
c. the work w done by the balloon is of indeterminate sign.
d. the balloon does no work.
e. none of these are correct.
Answer: b

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51. Given the following $\Delta H_f°$ values:

| | |
|---|---|
| $SiH_4(g)$ | 34.3 kJ $mol^{-1}$ |
| $SiO_2(s)$ | −910.9 kJ $mol^{-1}$ |
| $H_2O(l)$ | −285.8 kJ $mol^{-1}$ |

Also,

| | |
|---|---|
| $H_2O$ | $\Delta H_{vap}$ = 44.0 kJ $mol^{-1}$. |

Calculate $\Delta Hr°$ for $SiH_4(g) + 2O_2(g) <=> SiO_2(s) + 2H_2O(s)$.

a. −1517 kJ $mol^{-1}$
b. −1429 kJ $mol^{-1}$
c. −1187 kJ $mol^{-1}$
d. This cannot be determined without additional information.
e. none of these

Answer: d

52. The second law of thermodynamics states that
a. Energy increases during a spontaneous processes.
b. The temperature of the universe increases during a spontaneous process.
c. Heat and work are interconvertable.
d. At constant pressure, the heat transferred is equivalent to the change in enthalpy.
e. The entropy of a system plus the entropy of its surroundings increases during a spontaneous process.

Answer: e

53. For the vaporization of a liquid well above its normal boiling point $T_b$, the change in entropy and the change in enthalpy are related by
a. $\Delta Svap = \Delta Hvap * T_b$
b. $\Delta Svap = T_b / \Delta Hvap$
c. $\Delta Svap = \Delta Hvap / T_b$
d $T_b = \Delta Hvap * \Delta Svap$
e. none of these.

Answer: e

54. If ΔSuniv is positive for a process, the process is _____, if ΔSuniv for a process is negative, the process is _____, and if ΔSuniv for a process is zero, the process is _____ (For this question nonspontaneous means spontaneous in the reverse direction).
a. spontaneous, nonspontaneous, at equilibrium
b. at equilibrium, spontaneous, nonspontaneous
c. nonspontaneous, spontaneous, at equilibrium
d. spontaneous, at equilibrium, nonspontaneous
e. none of these

Answer: a

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55. A process can be spontaneous at low temperatures and at high temperatures if
a. both ΔH and ΔS are positive.
b. both ΔH and ΔS are negative.
c. ΔH is positive and ΔS is negative.
d. ΔH is negative and ΔS is positive.
e. ΔH is positive and ΔS is zero.
Answer: d

56. For the reaction below, K = $8.6 \times 10^{19}$ at T = 298 K and K = $1.09 \times 10^{15}$ at 398 K.

$$Cl_2(g) + F_2(g) \Longleftrightarrow 2ClF(g)$$

Assuming that $\Delta H_r°$ and $\Delta S_r°$ are independent of T over this range, sufficient information is given here to determine

a. $\Delta S_r°$, $\Delta H_r°$ and $\Delta G_r°$
b. $\Delta S_r°$ and $\Delta H_r°$ only
c. $\Delta G_r°$ only
d. $\Delta S_{sur}$
e. a and d
Answer: a

57. Oxidation is
a. loss of electrons
b. gain of electrons
c. loss of protons
d. gain of protons
e. none of these
Answer: a

58. Which element is oxidized in the reaction (unbalanced), $MnO_4^- + SO_4^{2-} \Longleftrightarrow Mn^{2+} + S_2O_8^{2-}$
a. Mn
b. O
c. S
d. None; this is not a redox reaction.
e. This cannot be determined without balancing the equation.
Answer: c

59. When $CrO_4^{2-}$ is converted to $Cr^{3+}$, _____ electrons are _____ by each chromium atom.
a. 5, lost
b. 5, gained
c. 3, lost
d. 3, gained
e. none of these.
Answer: d

60. The Entropy of a system is the thermodynamic property that constitutes a quantitative measure of the
a. heat content of the system.
b. degree of disorder of the system.
c. internal energy of the system.
d. all of these (a-c).
e. none of these (a-c).
Answer: b

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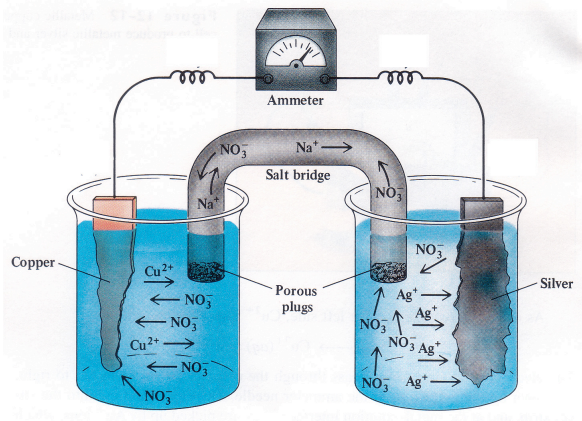
## Final Exam Section 4 (questions 61-80)

61. For the galavanic cell shown here predict the direction of electron flow if the reactants and products are in their standard states.




Standard Reduction Table

| Reaction | ε° (V) |
|---|---|
| $Br_2(l) + 2e^- \rightarrow 2Br^-(aq)$ | 1.06 |
| $Ag^+(aq) + 2e^- \rightarrow Ag(s)$ | 0.80 |
| $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ | 0.35 |
| $Zn^{2+}(aq) + 2e^- \rightarrow Zn(s)$ | -0.76 |

a. left to right.
b. right to left.
c. none (no electron flow).
d. cannot be determined.
Answer: a
Net reaction $2Ag^+(aq) + Cu(s) \rightarrow 2Ag(s) + Cu^{2+}(aq)$; electrons are transferred from Cu(s) to Ag(s).

62. For the galavanic cell shown here, what is the voltage if the reactants and products are in their standard states.
a. 1.15 V
b. 0.45 V
c. -0.45 V
d. –1.15 V
e. 0.80 V
Answer: b
$\Delta\varepsilon° = 0.80 - 0.35 = 0.45$

63. For the reaction in the Galvanic cell shown here, what is $\Delta G°_r$?
a. 43 kJ
b. 87 kJ
c. –87 kJ
d. 43 kJ
e none of these are correct.
Answer: c
$\Delta G°_r = -nF\Delta\varepsilon° = -2\ 96{,}458\ 0.45 = -87$ KJ

64. For the galavanic cell above, what is the voltage if reactants are in their standard states, and the products are 10 times more concentrated than that.
a. -0.42 V
b. -0.39 V
c. 0.39 V
d. 0.42V
e. none of these.
Answer: d
$\Delta\varepsilon = \Delta\varepsilon° - [(RT)(nF)^{-1}\ln(Q)]$
$\Delta\varepsilon = 0.45 - [(8.31\ J/K\text{-}mol\ 298\ K)(2\ mol^{-1}\ 96{,}458\ C\ mol\text{-}1)^{-1}\ln(10)]$
$\Delta\varepsilon = 0.45 - [(2476)(19300)^{-1}(\ln 10)]$
$\Delta\varepsilon = 0.45\text{-}(0.0128\ln 10) = 0.45 - (0.030) = 0.42$ V

65. For the reaction in the galavanic cell above, what is equilibrium constant?
a. $e^{-35}$
b. $e^{35}$
c. $e^{17}$
d. $e^{-17}$
e. none of those above
Answer: b

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K=exp(nFΔε°/RT) = exp[(2 96,458 0.45)/ (8.31 J/K-mol 298 K)]
=exp[(86812)/(2476)] = exp35

66. The standard cell voltage of a galvanic cell is related to the standard half-cell reduction potentials (ε°) by Δε° =

a. ε°(anode) - ε°(cathode)
b. ε°(cathode) - ε°(anode)
c. ε°(anode) + ε°(cathode)
d. ε°(anode) - ε°(cathode)
e. none of these

Answer: b

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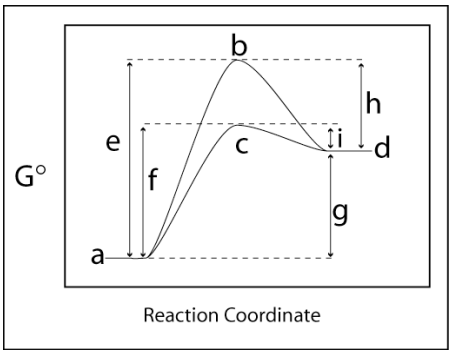
67. Electrical work is given by
a. $w_{elec} = Q\varepsilon$
b. $w_{elec} = -Q\Delta\varepsilon$
c. $w_{elec} = -Q/\Delta\varepsilon$
d. $w_{elec} = -\Delta\varepsilon/Q$
e. none of these
Answer: b

68. One joule per coulomb is
a. one faraday
b. one ampere
c. one volt
d. one watt
e. one mole
Answer: c

69. One kilowatt-hour is
a. 60 J
b. 1000 J
c. 3600 C
d. $3.6 \times 10^6$ C
e. none of these
Answer: e

70. For a certain reaction, a plot of ln [A] versus t gives a straight line with a slope of -3.6 and a y- intercept of 8.2. The rate constant for this reaction is
a. 1.8 $s^{-1}$
b. –1.8 $s^{-1}$
c. 4.1 $s^{-1}$
e. 3.6 $s^{-1}$
d. 8.2 $s^{-2}$
Answer: e




The following five questions relate to the reaction coordinate versus G° graph.

71. The reactant is ___. The catalyzed transition state is ___. The uncatalyzed transition state is ___. The product is ___.
a. species a, species b, species c, species d.
b. species a, species c, species b, species d.
c. species d, species b, species c, species a.
d. species d, species c, species b, species a.
e. none of those listed above.

Answer: b

72. For this reaction: $\Delta G°$ is ___. $\Delta G°_f^{\ddagger}$ is ___. $\Delta G°_r^{\ddagger}$ is ___. $\Delta G°_{f\ (catalyzed)}^{\ddagger}$ is ___.
a. f,e,h,g
b. f,h,e,g
c. g,e,f,h
d. g,e,h,f
e. none of those listed above.

Answer: d

73. For this reaction:
a. $\Delta G° > 0$
b. $\Delta G° < 0$
c. $\Delta G° = 0$
d. none of those listed above.
Answer: a

74. For this reaction
a. $\Delta G°_f^{\ddagger} > 0$
b. $\Delta G°_f^{\ddagger} < 0$
c. $\Delta G°_f^{\ddagger} = 0$
d. cannot be determined.
Answer: a

75. For this reaction
a. $\Delta G°_f^{\ddagger} > \Delta G_r^{\ddagger}$
b. $\Delta G°_f^{\ddagger} = \Delta G_r^{\ddagger}$
c. $\Delta G°_f^{\ddagger} < \Delta G_r^{\ddagger}$
d. cannot be determined.
Answer: a

76. Reaction rates can change with
a. temperature.
b. the addition of a catalyst or enzyme.
c. reactant concentrations.
d. all of those above (a-c).
e. none of those above (a-c).
Answer: d

77. Enzymes preferentially stabilize
a. reactants
b. products
c. transition states
d. a and b.
e. none of these.
Answer: c

78. Enzymes increase
a. forward rate constants
b. reverse rate constants
c. equilibrium constants
d. a and b.
e. none of these.
Answer: d

79. At constant T, reaction rate constants are
a. greatest at the beginning of a reaction and decrease with time.
b. smallest at the beginning and increase with time.
c. constant throughout a reaction.
d. observed to increase and decrease alternately as the reaction proceeds.
e. No such generalizations can be made.

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Answer: c

80. Which of the following rate laws is for a reaction that is first order in oxygen?

a. rate = k $[NO_2]$

b. rate = k $[NO_2]$ $[O_2]$

c. rate = k $[NO_2]$ $[O_2]^2$

d. rate = k $[NO_2]^2$ $[O_2]^2$ $[N_2]$

e. none of these.

Answer: b