

PRACTICE FINAL EXAM / CHEM1412 / SPRING 2015

1. What is the thermodynamic quantity that provides the criterion for the spontaneity of a chemical reaction?
 - a. ΔS
 - b. ΔH
 - c. ΔU
 - d. ΔG
 - e. $T\Delta S$
2. What is equal to ΔH at equilibrium?
 - a. ΔS
 - b. ΔH
 - c. ΔU
 - d. ΔG
 - e. $T\Delta S$
3. Which of the following must have a negative value for an exothermic reaction?
 - a. enthalpy change
 - b. entropy change
 - c. free energy change
 - d. electrode cell potential
 - e. equilibrium constant
4. Thermodynamics is applied to learn a reaction's
 - a. pathway.
 - b. mechanism.
 - c. stoichiometry.
 - d. rate.
 - e. feasibility.
5. For which of the following processes would the enthalpy changes be expected to be exothermic?
 1. $\text{Cl}^-(g) \Rightarrow \text{Cl}(g) + e$
 2. $\text{CO}_2(s) \Rightarrow \text{CO}_2(g)$
 3. $\text{Na}(g) \Rightarrow \text{Na}^+(g) + e$
 4. $2\text{Cl}(g) \Rightarrow \text{Cl}_2(g)$
 - a. 1 only
 - b. 4 only
 - c. 1 and 2 only
 - d. 2 and 3 only
 - e. 2, 3, and 4

6. Which of the following processes is endothermic?
- $\text{H}_2\text{O}(g) \Rightarrow \text{H}_2\text{O}(l)$
 - $\text{Al}^{3+}(g) + 3e^- \Rightarrow \text{Al}(s)$
 - $\text{NH}_3(g) + \text{HCl}(g) \Rightarrow \text{NH}_4\text{Cl}(s)$
 - $2\text{H}_2\text{O}(l) \Rightarrow 2\text{H}_2(g) + \text{O}_2(g)$
 - $\text{C}(s) + \text{O}_2(g) \Rightarrow \text{CO}_2(g)$
7. ΔH and ΔU are nearly the same in all the following processes **EXCEPT**
- $2\text{SO}_2(g) + \text{O}_2(g) \Rightarrow 2\text{SO}_3(g)$.
 - $\text{N}_2(g) + \text{O}_2(g) \Rightarrow 2\text{NO}(g)$.
 - $\text{CuO}(s) + \text{H}_2(g) \Rightarrow \text{Cu}(s) + \text{H}_2\text{O}(g)$.
 - $\text{CH}_4(g) + \text{Cl}_2(g) \Rightarrow \text{CH}_3\text{Cl}(g) + \text{HCl}(g)$.
 - $\text{C}_6\text{H}_6(s) \Rightarrow \text{C}_6\text{H}_6(l)$.
8. The heat of vaporization of Freon, CCl_2F_2 , is 17.2 kJ/mol at 25°C. What is the change of entropy for one mole of liquid Freon when it vaporizes at 25°C?
- 57.7 J/(mol-K)
 - 0.688 J/(mol-K)
 - 5.13×10^3 kJ/(mol-K)
 - 3.16 J/(mol-K)
 - 2.39×10^2 J/(mol-K)
9. Which of the following is true when one mole of $\text{CO}_2(g)$ changes to dry ice?
- The entropy decreases.
 - The entropy increases.
 - The enthalpy increases.
 - The enthalpy decreases.
- 1 only
 - 2 only
 - 1 and 3 only
 - 2 and 3 only
 - 1 and 4 only
10. The heat of vaporization of ammonia is 23.4 kJ/mol. Its boiling point is -33°C. The change in entropy for the vaporization of methanol in J/(mol-K) is
- 23.4.
 - 0.00975.
 - 0.0234.
 - 23.4.
 - 97.5.

11. For a reaction if $\Delta G^\circ = 0$, then

- a. $\Delta S^\circ = 0$.
- b. $\Delta H^\circ = 0$.
- c. $\Delta G^\circ = 0$.
- d. $K = 1$.
- e. $K = 0$.

12. For the reaction $3C(s) + 4H_2(g) \Rightarrow C_3H_8(g)$,

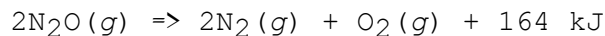
$$\Delta S = -269 \text{ J/(mol} \cdot \text{K)}$$

$$\Delta H = 103.8 \text{ kJ/mol}$$

Calculate the equilibrium constant at 25°C for the reaction above.

- a. 1.0
- b. 1.4×10^4
- c. 1.0×10^{17}
- d. 3.7×10^{19}
- e. 2.1×10^{32}

13. Calculate the heat of formation of nitrous oxide in kJ/mol from the following information:



- a. -164 kJ
- b. -82 kJ
- c. -41 kJ
- d. 82 kJ
- e. 164 kJ

14. For a reaction system that is at equilibrium, which of the following must always be true?

- a. $\Delta G = 0$
- b. $\Delta H = 0$
- c. $\Delta U = 0$
- d. $\Delta S = 0$
- e. $q = 0$

15. What is the minimum temperature required for the spontaneous conversion of $CCl_4(l)$ to $CCl_4(g)$ when ΔH° is 573 kJ/mol and ΔS° is 1.64 kJ/(mol \cdot K)?

- a. 76 °C
- b. 89 °C
- c. 189 °C
- d. 215 °C
- e. 349 °C

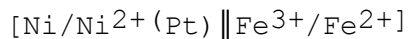
16. Which of the following is **TRUE** for a galvanic cell?

1. The electron flow is from the negative electrode to the positive electrode.
 2. The electron flow is from the anode to the cathode.
 3. The electron flow is from oxidizing agent to the reducing agent through an external circuit.
- a. 1 only
 - b. 2 only
 - c. 3 only
 - d. 1 and 2 only
 - e. 1, 2, and 3

17. The cathode in a galvanic cell and in an electrolytic (electrolysis) cell is

- a. positive in both cells.
- b. the site of oxidation and reduction, respectively.
- c. the site of reduction and oxidation, respectively.
- d. the site of oxidation.
- e. the site of reduction.

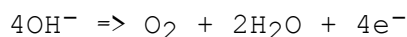
18. In the voltaic cell that is represented as



the electron flow will be from

- a. Pt to Ni^{2+} .
 - b. Pt to Ni.
 - c. Fe^{2+} to Ni^{2+} .
 - d. Ni^{2+} to Fe^{2+} .
 - e. Ni to Fe^{3+} .
19. In an electrochemical cell, which statement is **ALWAYS** true of the cathode?
- a. It is considered the "negative" electrode.
 - b. It is considered the "positive" electrode.
 - c. Reduction occurs here.
 - d. Metal is plated out here.
 - e. Negative ions flow toward the cathode.

20. What is the cell reaction for the voltaic cell $\text{Cr}(s)/\text{Cr}^{3+}(aq)//\text{Cl}^{-}(aq)/\text{Cl}_2(g)/(\text{Pt})$?
- a. $\text{Cr}(s) + 2\text{Cl}^{-}(aq) \Rightarrow \text{Cl}_2(g) + \text{Cr}^{3+}(aq)$
 - b. $2\text{Cr}^{3+}(aq) + 6\text{Cl}^{-}(aq) \Rightarrow 2\text{Cr}(s) + 3\text{Cl}_2(g)$
 - c. $\text{Cr}(s) + 3\text{Cl}_2(g) \Rightarrow \text{Cr}^{3+}(s) + 2\text{Cl}^{-}(aq)$
 - d. $2\text{Cr}(s) + 3\text{Cl}_2(g) \Rightarrow 2\text{Cr}^{3+}(aq) + 6\text{Cl}^{-}(aq)$
 - e. none of these
21. The numerical value of the Faraday constant is given as 96,500. This value represents
- a. the number of coulombs of charge carried by one mole of electrons.
 - b. the number of electrons corresponding to one coulomb of charge.
 - c. the number of electrons corresponding to one mole of electric charge.
 - d. the number of ions discharged by the passage of one mole of electrons.
 - e. 96,500 amp/s
22. When Au is obtained by electrolysis from NaAuCl_4 , the minimum number of coulombs required to produce 1.00 mol of gold is
- a. 48,250.
 - b. 96,500.
 - c. 193,000.
 - d. 290,000.
 - e. 579,000.
23. In the electrolysis of a basic solution, oxygen can be produced by the half-reaction



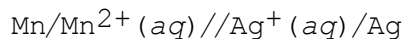
How many moles of O_2 can be produced from a solution that was electrolyzed for 6.00 hr using a current of 8.00 A?

- a. 1.49×10^{-2}
- b. 4.48×10^{-2}
- c. 0.224
- d. 0.448
- e. 0.896

24. Consider the following standard electrode potentials:



for the standard cell



Which of the following statements are true?

1. The cell voltage will be 1.98 V.
 2. The one cell reaction is $\text{Ag} \Rightarrow \text{Ag}^+ + \text{e}^-$.
 3. The overall cell potential will decrease with time.
- a. 1 only
 - b. 2 only
 - c. 3 only
 - d. 2 and 3 only
 - e. 1 and 3 only
25. Calculate the maximum electrical work obtainable when 7.10 g of $\text{Cl}_2(\text{g})$ are consumed in the reaction $\text{Cd}(\text{s}) + \text{Cl}_2(\text{g}) \Rightarrow \text{Cd}^{2+}(\text{aq}) + 2\text{Cl}^-(\text{aq})$. ($E^\circ_{\text{cell}} = 1.76 \text{ V}$.)
- a. $-3.40 \times 10^6 \text{ J}$
 - b. $-3.40 \times 10^4 \text{ J}$
 - c. $-1.70 \times 10^4 \text{ J}$
 - d. $-5.10 \times 10^5 \text{ J}$
 - e. $-1.10 \times 10^4 \text{ J}$
26. Calculate E° for the cell reaction $2\text{Cr} + 3\text{Sn}^{4+} \Rightarrow 3\text{Sn}^{2+} + 2\text{Cr}^{3+}$.

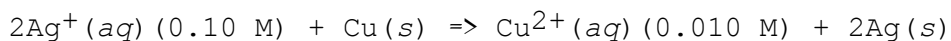


- a. 1.93 V
- b. 0.89 V
- c. 0.59 V
- d. 0.45 V
- e. -0.59 V

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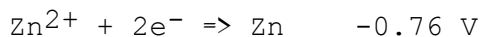
27. For a certain reaction, $\Delta H^\circ = -76.0 \text{ kJ}$ and $\Delta S^\circ = -234 \text{ J/K}$. If $n = 3$, calculate E° for the reaction at 25°C .
- a. 0.022 V
 - b. 0.032 V
 - c. 0.065 V
 - d. 0.096 V
 - e. 0.192 V

28. At 25°C , calculate the voltage of the cell



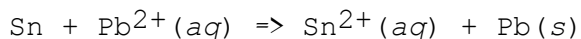
if $E^\circ_{\text{cell}} = 0.460 \text{ V}$.

- a. 0.282 V
 - b. 0.371 V
 - c. 0.430 V
 - d. 0.460 V
 - e. 0.519 V
29. What is the value of the reaction quotient, Q , for the cell that is constructed from the two half-reactions



when the Zn^{2+} concentration is 0.0100 M and the Ag^+ concentration is 1.25 M ?

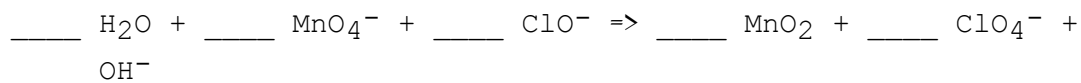
- a. 156
 - b. 125
 - c. 1.25×10^{-2}
 - d. 8.00×10^{-3}
 - e. 6.40×10^{-3}
30. Calculate the equilibrium constant K at 25°C for the reaction



where E°_{cell} equals 0.014 .

- a. 1.7
- b. 3.0
- c. 4.8
- d. 8.8
- e. 12

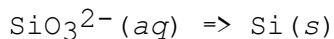
31. In Galvanic Cells, electrons flow from
- cathode to anode
 - anode to cathode
 - positive electrode to negative electrode
 - the more positive electrode potential to the more negative electrode potential
32. What is the reduction potential for the half-reaction $\text{Al}^{3+}(\text{aq}) + 3\text{e}^{-} \Rightarrow \text{Al}(\text{s})$ at 25°C if $[\text{Al}^{3+}] = 0.10 \text{ M}$ and $E^{\circ} = -1.66 \text{ V}$?
- 1.84
 - 1.60
 - 1.68
 - 1.66
 - 1.72
33. What reaction occurs at the anode during the electrolysis of aqueous CuSO_4 ?
- $2\text{H}_2\text{O} + 2\text{e}^{-} \Rightarrow \text{H}_2 + 2\text{OH}^{-}$
 - $\text{Cu} \Rightarrow \text{Cu}^{2+} + 2\text{e}^{-}$
 - $2\text{H}_2\text{O} \Rightarrow \text{O}_2 + 4\text{H}^{+} + 4\text{e}^{-}$
 - $2\text{H}^{+} + 2\text{e}^{-} \Rightarrow \text{H}_2$
 - $\text{Cu}^{2+} + 2\text{e}^{-} \Rightarrow \text{Cu}$
34. A current of 10. amperes is passed through molten magnesium chloride for 12.0 hours. How many moles of magnesium metal could be produced via this electrolysis?
- 2.2
 - 1.1
 - 0.56
 - 0.37
 - 0.22
35. The following reaction occurs in basic solution:



Balance the equation and then add together all the coefficients in the balanced equation. The sum of these coefficients is

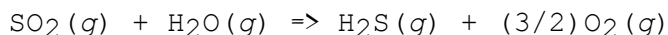
- 6.
- 9.
- 10.
- 12.
- 20.

36. The silicate ion can be reduced to silicon in basic solution. Each mole of silicate ions requires four moles of electrons. When the half-reaction



is balanced, it has

- a. 3 H₂O on the left and 6 OH⁻ on the right.
 - b. 4 H₂O on the left and 8 OH⁻ on the right.
 - c. 2 H₂O on the left and 4 OH⁻ on the right.
 - d. 4 OH⁻ on the left and 2 H₂O on the right.
 - e. 2 OH⁻ on the left and 1 H₂O on the right.
37. Consider the reaction of sulfur dioxide and water, which is represented by the equation



How many moles of electrons are transferred according to the equation that is written?

(Solution Rational: This reaction is very rare in the scheme of redox reactions... It has 2 reductions of oxygen on reactant side of the equation. That is, the two oxygen from SO₂ each lose 2e^{-s} (= 4e^{-s}) and the one oxygen of water loses 2e^{-s} for a total of total of 6e^{-s} for the oxidation process forming 3 neutral oxygen atoms. This charge transfer balances with the gain of 6e^{-s} by sulfur as it changes from +4 in the SO₂ to -2 in the H₂S. The above equation is typically written as 2SO₂(g) + 2H₂O(g) => 2H₂S(g) + 3O₂(g) which totals to 12 e^{-s} in redox process.)

- a. 2
- b. 4
- c. 6 \longleftarrow (6e^{-s} oxidation process = 6e^{-s} reduction process as written)
- d. 8
- e. 12

Remaining questions will be from Exams I and II... Have a great summer!

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1. d
2. e
3. a
4. e
5. b
6. d
7. a
8. a
9. e
10. e
11. d
12. b
13. d
14. a
15. a
16. d
17. e
18. e
19. c
20. d
21. a
22. d
23. d
24. e
25. b
26. b
27. a
28. d
29. e
30. b
31. b
32. c
33. c
34. a
35. b
36. a
37. c (special problem)