

Read questions carefully to understand what is being asked, before answering. No outside paper is allowed. Use the reverse side of your answer paper as scratch. Use the important equation table and periodic table provided. (Total points = 58 + (20x3=)60 = 118).

Show your calculation first with set up equation. Then use the raw data with units in the equation in the equation and then complete the calculation.

1) How many moles of NH_4Cl must be added to 2.0 L of 0.10 M ammonia (NH_3) to form a buffer, whose $\text{pH}=9.0$? Assume that no volume change happens when NH_4Cl is added into the solution). K_b of NH_3 is 1.8×10^{-5} (8 pts) 1) _____

2) If K_{sp} of calcium phosphate, $\text{Ca}_3(\text{PO}_4)_2$ in water is 1.0×10^{-33} , then what is its solubility in water in gram/L (10 pts)? 2) _____

3) The following information is available for the reaction at 25°C:

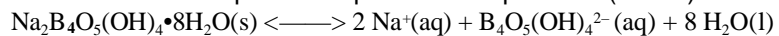
	$\text{CaCO}_3 (\text{s}) \rightleftharpoons \text{CaO} (\text{s}) + \text{CO}_2 (\text{g})$		
ΔG_f° (kJ/mol)	-1129.16	-603.42	-394.36
ΔH_f° (kJ/mol)	-1207.6	-635.09	-393.51
S_f° (J/K.mol)	91.7	38.2	213.74

3) _____

(a) Calculate the Gibbs free energy change of the reaction (3pts.) .

(b) Calculate the temperature in °C when the reaction will be favorable (5 pts.).

4) A nonlinear best fit plot of K_{eq} versus Temperature (Kelvin) of tetraborate equilibrium:



gives $\Delta H^\circ = 96 \text{ kJ/mol}$ and $\Delta S^\circ = 300 \text{ J/mol}$. From this data calculate the K_{eq} at 25° C .

Show set up, raw data and units. (8 pts.)

4) _____

5) Given $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O(l)$ $E_{red}^0 = +1.23 V$ 5) _____



For redox reaction: $4Ag(s) + O_2(g) + 4H^+(aq) \rightarrow 4Ag^+(aq) + 2H_2O(l)$

(i) Write the cathode reaction (2 pts.):

(ii) Write the anode reaction (2 pts.):

iii) Show set up and all your work to calculate the standard free energy change for the reaction at 25°C (4 pts.)

(iv) Show set up and all your work to calculate the equilibrium constant for the reaction at 25°C (8 pts.)

6) How many seconds are required to produce 4.00 g of aluminum metal from the electrolysis of molten $AlCl_3$ with an electrical current of 12.0 A? Show set up and all your work. (8 pts.) 6) _____

MULTIPLE CHOICE. On the scantron fill the bubble with number same as the question number. Show your work to select the one response that best completes the statement or answers the question (3 pts each).

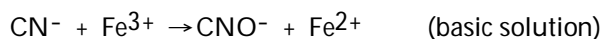
- 7) A solution containing which one of the following pairs of substances will be a buffer solution? 7) _____
- A) KBr, HBr
 - B) CsF, HF
 - C) NaI, HI
 - D) RbCl, HCl
 - E) none of the above

- 8) In which of the following aqueous solutions would you expect PbCl_2 to have the lowest solubility? 8) _____
- A) 0.015 M NaCl
 - B) 0.020 M BaCl_2
 - C) pure water
 - D) 0.015 M PbNO_3
 - E) 0.020 M KCl

- 9) Which below best describe(s) the behavior of an amphoteric hydroxide in water? 9) _____
- A) With conc. aq. HCl, its suspension dissolves.
 - B) With conc. aq. HCl, its clear solution forms a precipitate.
 - C) With conc. aq. NaOH, its clear solution forms a precipitate.
 - D) With conc. aq. NaOH, its suspension dissolves.
 - E) With both conc. aq. NaOH and conc. aq. HCl, its suspension dissolves.

- 10) What is the oxidation number of nitrogen in the HNO_3 ? 10) _____
- A) -1 B) +1 C) +5 D) +7 E) +3

- 11) What is the coefficient of Fe^{3+} when the following equation is balanced? 11) _____



- A) 1 B) 2 C) 3 D) 4 E) 5

- 12) Which transformation could take place at the cathode of an electrochemical cell? 12) _____

- A) $\text{Mn}^{2+} \rightarrow \text{MnO}_4^-$
- B) $\text{MnO}_2 \rightarrow \text{MnO}_4^-$
- C) $\text{Br}_2 \rightarrow \text{BrO}_3^-$
- D) $\text{HSO}_4^- \rightarrow \text{H}_2\text{SO}_3$
- E) $\text{NO} \rightarrow \text{HNO}_2$

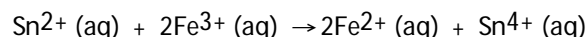
Table 20.2

Half-reaction	E° (V)
$\text{Cr}^{3+}(\text{aq}) + 3\text{e}^- \rightarrow \text{Cr}(\text{s})$	-0.74
$\text{Fe}^{2+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Fe}(\text{s})$	-0.440
$\text{Fe}^{3+}(\text{aq}) + \text{e}^- \rightarrow \text{Fe}^{2+}(\text{s})$	+0.771
$\text{Sn}^{4+}(\text{aq}) + 2\text{e}^- \rightarrow \text{Sn}^{2+}(\text{aq})$	+0.154

13) Which of the following reactions will occur spontaneously as written? 13) _____

- A) $\text{Sn}^{4+}(\text{aq}) + \text{Fe}^{2+}(\text{s}) \rightarrow \text{Sn}^{2+}(\text{aq}) + \text{Fe}(\text{s})$
 B) $2\text{Cr}(\text{s}) + 3\text{Fe}^{2+}(\text{s}) \rightarrow 3\text{Fe}(\text{s}) + 2\text{Cr}^{3+}(\text{aq})$
 C) $2\text{Cr}^{3+}(\text{aq}) + 3\text{Sn}^{2+}(\text{aq}) \rightarrow 3\text{Sn}^{4+}(\text{aq}) + 2\text{Cr}(\text{s})$
 D) $\text{Sn}^{2+}(\text{aq}) + \text{Fe}^{2+}(\text{s}) \rightarrow \text{Sn}^{4+}(\text{aq}) + \text{Fe}^{3+}(\text{aq})$
 E) $3\text{Fe}^{2+}(\text{aq}) + \text{Cr}^{3+}(\text{aq}) \rightarrow \text{Cr}(\text{s}) + 3\text{Fe}^{3+}(\text{aq})$

14) The standard cell potential (E°_{cell}) for the voltaic cell based on the reaction below is _____ V. 14) _____

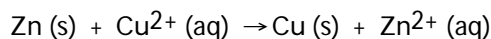


- A) +1.21 B) +0.617 C) +0.46 D) +1.39 E) -0.46

15) The reduction half reaction occurring in the standard hydrogen electrode is _____. 15) _____

- A) $\text{H}_2(\text{g}, 1 \text{ atm}) \rightarrow 2\text{H}^+(\text{aq}, 1\text{M}) + 2\text{e}^-$
 B) $2\text{H}^+(\text{aq}) + 2\text{OH}^- \rightarrow \text{H}_2\text{O}(\text{l})$
 C) $2\text{H}^+(\text{aq}, 1\text{M}) + \text{Cl}_2(\text{aq}) \rightarrow 2\text{HCl}(\text{aq})$
 D) $2\text{H}^+(\text{aq}, 1\text{M}) + 2\text{e}^- \rightarrow \text{H}_2(\text{g}, 1 \text{ atm})$
 E) $\text{O}_2(\text{g}) + 4\text{H}^+(\text{aq}) + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}(\text{l})$

16) The standard cell potential (E°_{cell}) for the reaction below is +1.10 V. The cell potential for this reaction is _____ V when the concentration of $[\text{Cu}^{2+}] = 1.0 \times 10^{-5} \text{ M}$ and $[\text{Zn}^{2+}] = 1.0 \text{ M}$. 16) _____



- A) 0.95 B) 0.80 C) 1.25 D) 1.10 E) 1.40

17) The thermodynamic quantity that expresses the degree of disorder in a system is _____. 17) _____

- A) bond energy
 B) entropy
 C) internal energy
 D) enthalpy
 E) heat flow

18) The normal boiling point of water is 100.0°C and its molar enthalpy of vaporization is 40.67 kJ/mol . What is the change in entropy in the system in J/K when 39.3 grams of steam at 1 atm condenses to a liquid at the normal boiling point? 18) _____

- A) 373 B) 88.8 C) -40.7 D) -88.8 E) -238

- 19) ΔS is positive for the reaction _____. 19) _____
- A) $2\text{NO}_2(\text{g}) \rightarrow \text{N}_2\text{O}_4(\text{g})$
 - B) $2\text{Hg}(\text{l}) + \text{O}_2(\text{g}) \rightarrow 2\text{HgO}(\text{s})$
 - C) $\text{BaF}_2(\text{s}) \rightarrow \text{Ba}^{2+}(\text{aq}) + 2\text{F}^{-}(\text{aq})$
 - D) $\text{CO}_2(\text{g}) \rightarrow \text{CO}_2(\text{s})$
 - E) $2\text{H}_2(\text{g}) + \text{O}_2(\text{g}) \rightarrow 2\text{H}_2\text{O}(\text{g})$

- 20) Of the following, the entropy of _____ is the largest. 20) _____
- A) $\text{HCl}(\text{s})$
 - B) $\text{HCl}(\text{g})$
 - C) $\text{HCl}(\text{l})$
 - D) $\text{HBr}(\text{g})$
 - E) $\text{HI}(\text{g})$

- 21) The standard Gibbs free energy of formation of _____ is zero. 21) _____

- (a) $\text{H}_2\text{O}(\text{l})$
- (b) $\text{Na}(\text{s})$
- (c) $\text{H}_2(\text{g})$

- A) (a) only
- B) (b) only
- C) (c) only
- D) (b) and (c)
- E) (a), (b), and (c)

TRUE/FALSE. Select A in the scantron if the statement is TRUE and B if the statement is FALSE (3 pts).

- 22) The solubility product of a compound is numerically equal to the product of the concentration of the ions involved in the equilibrium, each multiplied by its coefficient in the equilibrium reaction. T or F
- 23) The vaporization of a substance at its boiling point is an isothermal process T or F
- 24) The more negative ΔG° is for a given reaction, the larger the value of the corresponding equilibrium constant, K . T or F
- 25) The standard reduction potential, E°_{red} , is proportional to the stoichiometric coefficient. T or F
- 26) The standard reduction potential of X is 1.23 V and that of Y is -0.44 V therefore X is oxidized by Y. T or F