Exam 3

# Part 1: Multiple Choice (2 points each)

## Directions: Please circle the *best* answer for each of the following questions.

1. If you inadvertently dispose of a chemical into the incorrect waste container, you should
2. make a note of this in your lab notebook.
3. tell you instructor before the end of the laboratory session.
4. tell your instructor immediately.
5. write an email to your instructor so that there is a legal statement about the event.
6. ignore it; it’s probably fine.
7. According to the third law of thermodynamics,
   1. energy is conversed in any transformation of matter.
   2. the entropy increases for any spontaneous process.
   3. the entropy of a perfectly ordered, crystalline substance is zero at zero Kelvin.
   4. the entropy of the universe increases for any spontaneous process.
   5. all of the above
8. Time moves in the direction of
   1. increasing entropy of the universe.
   2. increasing internal energy of the universe.
   3. decreasing entropy of the universe.
   4. decreasing internal energy of the universe.
   5. none of the above
9. Rank the following in order of increasing standard molar entropy (S°): H2O (g), H2O (l), H2O (s)
   1. H2O (g), H2O (l), H2O (s)
   2. H2O (l), H2O (g), H2O (s)
   3. H2O (s), H2O (l), H2O (g)
   4. not enough information
   5. none of the above
10. Under what conditions, if any, will the entropy of H2O (l) equal the entropy of H2O (g)?
    1. At the critical point for water
    2. At the normal boiling point of water
    3. At the triple point of water
    4. none of the above
    5. all of the above
11. What is the W in the Boltzmann’s formula, S= k ln W?
    1. A fraction indicating the probability of obtaining a result.
    2. A random fraction
    3. The number of ways of obtaining the state.
    4. The work times Avogadro’s number.
    5. all of the above
12. Julian says, “An oxidizing agent contains the molecule that is being \_\_\_\_\_\_\_.”
    1. reduced
    2. oxidized
    3. spontaneous
    4. diluted
    5. all of the above
13. Jessica asks, “What is the standard hydrogen electron equation?”
    1. 2 H+ (aq) + 2 e- → H2 (g) E° = 1 V
    2. 2 H+ (aq) + 4 e- → H2 (g) E° = 0 V
    3. 2 H+ (aq) + 2 e- → H2 (g) E° = 0 V
    4. H+ (aq) + e- → H2 (g) E° = 1 V
    5. H2 (g) → 2 H+ (aq) + 2 e- E° = 0 V
14. Kristine and Juliet found the standard cell potential, E°, of a reaction to be -0.11 V. For this reaction, the value of ΔG° is expected to be \_\_\_\_\_\_\_\_\_\_\_\_ and that of K is expected to be \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
    1. negative, greater than one
    2. positive, less than one
    3. negative, less than one
    4. positive, greater than one
    5. none of the above
15. Autumn is trying to prevent the corrosion of her new metal sculpture. What process(es) can she use?
    1. metal plating
    2. alloying
    3. paint it
    4. a concentration gradient
    5. a, b, and c

# Part 2: Short Answer

## Directions: Answer each of the following questions. Be sure to use complete sentences where appropriate. For full credit be sure to show all of your work.

1. The decomposition of sulfuryl chloride, SO2Cl2, is first order in SO2Cl2 and has a rate constant of 1.42 × 10-4 s-1 at a certain temperature (8 points).
   1. What is the half-life for this reaction?
   2. How long will it take for the concentration of SO2Cl2 to decrease to 25% of its initial concentration?

This is a first order reaction, so

1. Without doing any calculations, determine the signs of ΔSsys and ΔSsurr for each of chemical reaction. In addition, predict under what temperatures (all temperatures, low temperature, or high temperatures, if any, the reaction is spontaneous (4 points).
   1. C3H8 (g) + 5 O2 (g) → 3 CO2 (g) + 4 H2O (g) ΔH°rxn = -2044 kJ

ΔSsys < 0, and ΔSsurr > 0, spontaneous at all temperatures

* 1. N­2 (g) + O2 (g) → 2 NO (g) ΔH°rxn = +182.6 kJ

ΔSsys < 0, and ΔSsurr < 0, nonspontaneous at all temperatures

1. The temperature dependence of the equilibrium constant of the reaction:

2 CO2 (g) 2 CO (g) + O2 (g)

can be expressed as ln(Kp) = 20.1 - 66,662/(T/K) (8 points).

1. What is the standard enthalpy in kJ/mol of the forward process?
2. What is the standard entropy of the forward process?
3. Deposits of elemental sulfur are often seen near active volcanoes. Their presence there may be due to the following reaction of SO2 with H2S (8 points):

SO2 (g) + 2 H2S (g) → 3 S (s) + 2 H2O (l)

|  |  |
| --- | --- |
| Substance | ∆S° |
| SO2 (g) | 248.2 J/mol K |
| H2S (g) | 205.6 J/mol K |
| S (s) | 32.1 J/mol K |
| H2O (l) | * 1. J/mol K |

* + - 1. Nicolle wants to calculate ∆S° for this reaction.

∆Srxn° = [(3 mol S)(∆S° S (s)) + (2 mol H2O)(∆S° H2O (l))] - [(1 mol SO2 (g))(∆S° SO2 (g)) + (1 mol H2S)(∆S° H2S (g))]

∆Srxn° = [(3 mol S)(32.1 J/mol K) + (2 mol H2O)(188.8 J/mol K)] - [(1 mol SO2 (g))(248.2 J/mol K) + (2 mol H2S)(205.6 J/mol K)]

∆Srxn° = -185.5 J/K

* + - 1. Does this reaction result in an increase or decrease in entropy? Decrease

1. Firefly luciferase is the enzyme that allows fireflies to illuminate their abdomens. Because this light generation is an ATP-requiring reaction, firefly luciferase can be used to test for the presence of ATP. In this way, luciferase can test for the presence of life. The coupled reactions are (8 points):

luciferin + O2 (g) oxyluciferin + light

ATP AMP + PPi

1. If the overall ΔG of the coupled reaction is -5.20 kJ/mol and the ΔG for the oxidation of luciferin to oxyluciferin is 26.4 kJ/mol , what is ΔG for the ATP reaction?
2. Isabella wants to know what is the equilibrium constant, K, of the second reaction at room temperature, 25 °C?
3. Carlye created a Galvanic Cell based on the reaction (6 points):

MnO4- (aq) + Fe (s) → Mn2+ (aq) + Fe2+ (aq)

* 1. Balance the reaction in acidic conditions:

Red: **(**MnO4- (aq) + 8 H+ (aq) + 5 e- → Mn2+ (aq) + 4 H2O (l)**) × 2**

Ox: + **(**Fe (s) → Fe2+ (aq) + 2 e-**) × 5**

Net: 2 MnO4- (aq) + 16 H+ (aq) + 5 Fe (s) 2 Mn2+ (aq) + 8 H2O (l) + 5 Fe2+ (aq)

* 1. What is the line notation? Fe (s) | Fe2+ (aq) || H+ (aq), MnO4- (aq), Mn2+ (aq) | Pt (s)

1. Eric wants to know that is the purpose of the salt bridge in the Voltaic Cell (3 points)?

The purpose of the salt bridge is to all ions to flow between the two half cells and balance the positive and negative changes from building in the cathode and anode.

Use the following reduction potentials in the problems below:

Cl2 (g) + 2 e- → 2 Cl- (aq) E° = 1.36 V

Ag+ (aq) + e- → Ag (s) E° = 0.7994 V

Cu2+ (aq) + 2 e- → Cu (s) E° = 0.337 V

Pb2+ (aq) + 2 e- → Pb (s) E° = -0.13 V

Ni2+ (aq) + 2 e- → Ni (s) E° = -0.257 V

Al3+ (aq) + 3 e- → Al (s) E° = -1.662 V

1. Taylor and Lory constructed a Voltaic cell that consists of a Pb/Pb2+  half-cell and a Cu/Cu2+ half-cell at 25 °C (14 points).
   1. Angel asks, “What are the anode and that cathode?”

Cu2+ (aq) + 2 e- → Cu (s) E° = 0.337 V

Pb2+ (aq) + 2 e- → Pb (s) E° = -0.13 V

Net ionic equation: Cu2+ (aq) + Pb (s) → Cu (s) + Pb2+ (aq)

So, lead is being oxidized and is the anode. Copper is being reduced and is the cathode.

* 1. What is the standard cell potential.
  2. The initial concentrations of Pb2and Cu2+ are 0.0525 M and 1.60 M, respectively. What is the initial cell potential?
  3. What is the cell potential when the concentration of Cu2+ has fallen to 0.245 M?

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Cu2+ (aq) + | Pb (s) → | Cu (s) | + Pb2+ (aq) |
| I | 1.60 M | n/a | n/a | 0.0525 M |
| C | -x | n/a | n/a | +x |
| E | 0.245 M | n/a | n/a | = 0.0525 M + 1.36 M  = 1.41 V |

1. Luis’ friend Areej wants to build a perpetual motion machine (a machine that constantly moves without any energy input). Explain why perpetual motion machines do not work (3 points).

A perpetual motion machine cannot work because if the machine is in motion, it must pay the energy (heat) tax with each cycle of its motion. Over time, it will stop moving.

1. Vinny, Bliss, and Kyla know that ΔH°rxn = -115 kJ, ΔS°rxn = -263 J/K and T = 615 K for a reaction. Assume that all reactants and products are in their standard states (10 points).
   1. What is ΔSuniverse?
   2. Brandon wants to know ΔG°rxn.
   3. Jorge asks if the reaction is spontaneous?

A negative ΔG°rxn indicates that the process will be spontaneous.

1. Derrick and Reyna ask, “What is one difference between a Voltaic and Electrolytic Cell?” (4 points).

A Voltaic cell converts chemical energy to electrical energy by means of an oxidation-reduction reaction. It has a negatively charged anode and a positively charged cathode. The redox reaction is spontaneous.

An electrolytic cell uses electrical energy to drive a nonspontaneous reaction. Electrons are drawn off the anode at the positive terminal of the battery. Electrons are forced toward the cathode at the negative terminal of the battery.