Chem 121 Exam 2 Practice Problems. *(They are intended to be a guide and provide you with typical types of questions. The collection is not comprehensive, nor all inclusive, nor a facsimilie of the Exam, but should provide you with an idea of what to expect. Answers are NOT provided. If you have questions regarding the process to solve any of the problems, please see Dr. R.)*

Consider the gas phase reaction $NO + \frac{1}{2} O_2 \rightleftharpoons NO_2$ for which $\Delta H° = -57.03$ kJ and $K = 1.46 \times 10^6$ at 25°C.

1. Calculate $\Delta H°$ at 25°C for the following reaction:
   $2NO + O_2 \rightleftharpoons 2NO_2$
   a) 57.03 kJ
   b) –114.1 kJ
   c) –28.5 kJ
   d) 3252 kJ
   e) none of these

2. Calculate K for the following reaction at 25°C:
   $2NO + O_2 \rightleftharpoons 2NO_2$
   a) 2.92×10^6
   b) 2.13×10^{12}
   c) 7.30×10^5
   d) 1.21×10^3
   e) 1.46×10^6

3. Calculate $\Delta G°$ at 25°C for the following reaction:
   $2NO + O_2 \rightleftharpoons 2NO_2$
   a) –70.3 kJ
   b) –5.90 kJ
   c) –35.2 kJ
   d) 5.90 kJ
   e) 70.3 kJ

4. For this system at equilibrium, how will raising the temperature affect the amount of NO present?
   a) The amount of NO will increase.
   b) The amount of NO will decrease.
   c) The amount of NO will remain the same.
   d) Cannot be determined.
   e) Answer depends on the value of K.

5. Balance the following oxidation-reduction equation, then answer the related question.

   $$\_\_\ Mn^{2+}(aq) + \_\_\ S_2O_8^{2-}(aq) + \_\_\ H_2O(l) \rightarrow \_\_\ MnO_2(s) + \_\_\ H^+(aq) + \_\_\ SO_4^{2-}(aq)$$

   Which of the following is true?

   A. $Mn^{2+}(aq)$ is the oxidizing agent, $S_2O_8^{2-}(aq)$ is reduced, and 2 e- are transferred
   B. $Mn^{2+}(aq)$ is the oxidizing agent, $S_2O_8^{2-}(aq)$ is oxidized, and 3 e- are transferred
   C. $Mn^{2+}(aq)$ is the reducing agent, $S_2O_8^{2-}(aq)$ is oxidized, and 3 e- are transferred
   D. $Mn^{2+}(aq)$ is the reducing agent, $S_2O_8^{2-}(aq)$ is reduced, and 2 e- are transferred

6. Which energy conversion shown below takes place in a galvanic cell?

a) electrical to chemical
b) chemical to electrical
c) mechanical to chemical
d) chemical to mechanical
e) mechanical to electrical

7. A voltaic cell prepared using aluminum and nickel has the following cell notation.

$Al(s) \mid Al^{3+}(aq) \parallel Ni^{2+}(aq) \mid Ni(s)$

Which of the following represents the correctly balanced equation for the spontaneous reaction in the cell?

A. $Ni^{2+}(aq) + Al(s) \rightarrow Al^{3+}(aq) + Ni(s)$
B. $3Ni^{2+}(aq) + 2Al(s) \rightarrow 2Al^{3+}(aq) + 3Ni(s)$
C. $Ni(s) + Al^{3+}(aq) \rightarrow Ni^{2+}(aq) + Al(s)$
D. $3Ni(s) + 2Al^{3+}(aq) \rightarrow 3Ni^{2+}(aq) + 2Al(s)$

8. A voltaic cell can be prepared from copper and tin. What is the $E°_{cell}$ for the cell that forms from the following half reactions?

$Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ $E° = 0.34$ V
$Sn^{4+}(aq) + 2e^- \rightarrow Sn^{2+}(aq)$ $E° = 0.13$ V

A. 0.47 V B. 0.21 V C. –0.21 V D. –0.47 V

9. Calculate $E°_{cell}$ and indicate whether the overall reaction shown is spontaneous or nonspontaneous.

$I_2(s) + 2e^- \rightarrow 2I^-(aq)$ $E° = 0.53$ V
$Cr^{3+}(aq) + 3e^- \rightarrow Cr(s)$ $E° = -0.74$ V

Overall reaction:

$2Cr(s) + 3I_2(s) \rightarrow 2Cr^{3+}(aq) + (aq) + 6I^-(aq)$

A. $E°_{cell} = -1.27$ V, spontaneous
B. $E°_{cell} = -1.27$ V, nonspontaneous
C. $E°_{cell} = 1.27$ V, spontaneous
D. $E°_{cell} = 1.27$ V, nonspontaneous

10. The value of $E°_{cell}$ for the reaction
$2Cr^{3+}(aq) + 6Hg(l) \rightarrow 2Cr(s) + 3Hg_2^{2+}(aq)$
is 1.59 V. Calculate $\Delta G°$ for the reaction.

A. -921 kJ B. -767 kJ C. -460 kJ D. -307 kJ

11. Rank the following from the weakest to the strongest oxidizing agents

$[PtCl_4]^{2-}(aq) + 2e^- \rightarrow Pt(s) + 4Cl^-(aq)$ $E° = 0.755$ V
$RuO_4(s) + 8H^+(aq) + 8e^- \rightarrow Ru(s) + 4H_2O(l)$ $E° = 1.038$ V
$FeO_4^{2-}(aq) + 8H^+(aq) + 3e^- \rightarrow Fe^{3+}(aq) + 4H_2O(l)$ $E° = 2.07$ V
$H_4XeO_6(aq) + 2H^+(aq) + 2e^- \rightarrow XeO_3(aq) + 3H_2O(l)$ $E° = 2.42$ V

A. $[PtCl_4]^{2-}(aq) < RuO_4(s) < FeO_4^-(aq) < H_4XeO_6(aq)$
B. $RuO_4(s) < FeO_4^-(aq) < H_4XeO_6(aq) < [PtCl_4]^{2-}(aq)$
C. $FeO_4^-(aq) < H_4XeO_6(aq) < RuO_4(s) < [PtCl_4]^{2-}(aq)$
D. $H_4XeO_6(aq) < FeO_4^-(aq) < RuO_4(s) < [PtCl_4]^{2-}(aq)$

12. A concentration cell consists of two Zn/Zn^{2+} electrodes. The electrolyte in compartment A is 0.10 *M* $Zn(NO_3)_2$ and in compartment B is 0.60 *M* $Zn(NO_3)_2$. What is the voltage of the cell at 25°C?

A. 0.010 V
B. 0.020 V
C. 0.023 V
D. 0.046 V

13. A Chem 121 student undertook an experiment to determine when a AA battery would be considered "dead", that is, when it no longer provides power. Which of the following is a correct prediction?

A. $Q < 1$ B. $Q = 1$ C. $Q > 1$ D. $Q = K$

14. Provide the information requested for the following oxidation-reduction equation:

$Cr^{3+}(aq) + NO_3^{1-}(aq) \rightarrow NO(g) + Cr_2O_7^{2-}(aq)$ ($E°_{rxn} = -0.37$V, acidic solution)

Identify the oxidizing agent. _____
Identify the substance that is oxidized. _____
How many electrons (total) are transferred in the reaction? _____
Is the reaction spontaneous? _____
Does chromium(III)nitrate produce a gas when mixed with nitric acid? Circle one. Yes/ No. Briefly explain why or why not?

15. Which best describes a voltaic cell that is composed of two active metal electrodes?

A. electrons flow from the cathode to the anode, the solid metal anode will loose mass as the voltaic cell produces power, a concentration cell always has electrons flow from the compartment with the lower concentration to the compartment with the higher concentration.
B. electrons flow from the anode to the cathode, the solid metal anode will loose mass as the voltaic cell produces power, a concentration cell always has electrons flow from the compartment with the lower concentration to the compartment with the higher concentration.
C. electrons flow from the anode to the cathode, the solid metal anode will loose mass as the voltaic cell produces power, a concentration cell always has electrons flow from the compartment with the higher concentration to the compartment with the lower concentration.
D. electrons flow from the anode to the cathode, the solid metal cathode will loose mass as the voltaic cell produces power, a concentration cell always has electrons flow from the compartment with the higher concentration to the compartment with the lower concentration.

16. The line notation, Mg(s) | Mg^{2+}(aq) || Fe^{2+}(aq) | Fe(s), indicates that

A. iron metal is the reducing agent
B. Fe^{2+} ions are oxidized
C. magnesium metal is the reducing agent
D. Mg^{2+} ion is the reducing agent
E. magnesium metal is the cathode

17. For the reaction $2Na(s) + 2H_2O(l) \rightarrow 2Na^{+}(aq) + 2OH^{-}(aq) + H_2(g)$, $E° = +1.88$ V. If the standard reduction potential for sodium metal is -2.71 V, calculate the standard reduction potential for water.

A. 0.83 V B. -4.59 V C. -0.83 V D. -0.42 V E. 1.70 V

18. The value of ΔG^{o} for an oxidaton-reduction reaction, which involves the transfer of 2 electrons, is -48.25 kJ/mol. Calculate the standard cell potential for this reaction.

A. $E^{o} = +0.500$ V
B. $E^{o} = -0.500$ V
C. $E^{o} = +0.250$ V
D. $E^{o} = -0.250$ V
E. $E^{o} = +0.125$ V
F. $E^{o} = -0.125$ V

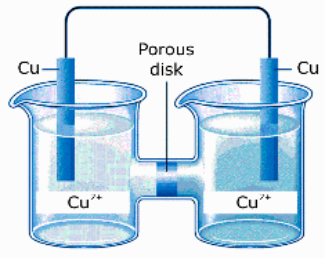
19. If an amount of hydrogen equal to an amount that is used in a fuel cell were burned by ignition in an automobile, the following statement is true.

A. Burning produces less energy than the fuel cell
B. Burning produces more energy than the fuel cell
C. Burning produces the same amount of energy as the fuel cell
D. Cannot determine any difference without knowing the mass of hydrogen used.

20. What amperage is required to plate out 104 g of Cr metal (Atomic Mass = 52.0 g/mol) from a saturated Cr^{3+} solution in a period of 10.0 hr?

A. 965 A B. 16.0 A C. 8.0 A D. 1.60 A E. 96.5 A

21. The concentration cell shown below employs copper metal electrodes in both compartments of the cell. The compartment on the left contains 0.0010 M Cu^{2+}(aq) and the compartment on the right contains 0.10 M Cu^{2+}(aq). Calculate the potential for the cell. Show your calcualtion.



$Cu^{2+}(aq) + 2e^{-} \rightarrow Cu(s)$ $E^{o} = +0.34$ V
$Cu^{2+}(aq) + 1e^{-} \rightarrow Cu^{1+}(aq)$ $E^{o} = +0.13$ V
$Cu^{1+}(aq) + 1e^{-} \rightarrow Cu(s)$ $E^{o} = +0.21$ V

$E^{o}_{cell} =$

What are the Cu^{2+}(aq) concentrations (mol/L) of the compartments when the cell can no longer deliver power?

22. Which of the following is true for the cell shown below?

$$Zn(s) \mid Zn^{2+}(aq) \parallel Cr^{3+}(aq) \mid Cr(s)$$

a) The electrons flow from the cathode to the anode.
b) The electrons flow from the zinc to the chromium.
c) The electrons flow from the chromium to the zinc.
d) The chromium is oxidized.
e) The zinc is reduced.

23. The reduction potentials for Au^{3+} and Ni^{2+} are as follows:

$$Au^{3+} + 3e^- \rightarrow Au \qquad E° = +1.50 \text{ V}$$

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

Calculate $\Delta G°$ (at 25°C) for the reaction:

$$2Au^{3+} + 3Ni \rightarrow 3Ni^{2+} + 2Au$$

a) -5.00×10^2 kJ
b) $+5.00 \times 10^2$ kJ
c) –2140 kJ
d) $+1.00 \times 10^3$ kJ
e) -1.00×10^3 kJ

24. For a reaction in a voltaic cell both ΔH° and ΔS° are positive. Which of the following statements is true?
a) E°cell will increase with an increase in temperature.
b) E°cell will decrease with an increase in temperature.
c) E°cell will not change when the temperature increases.
d) ΔG° > 0 for all temperatures.
e) None of the above statements is true.

25. Consider the reaction: $4NH_3 + 7O_2 \rightarrow 4NO_2 + 6H_2O$
At a certain instant the initial rate of disappearance of the oxygen gas is X. What is the value of the appearance of water at the same instant?

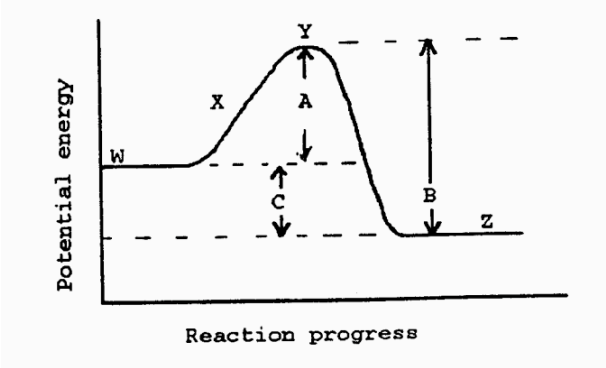
a) 1.2 X
b) 1.1 X
c) 0.86 X
d) 0.58 X
e) cannot be determined from the data

26. The following data were obtained for the reaction of NO with O_2. Concentrations are in molecules/cm^3 and rates are in molecules/cm^3·s.

$[NO]_0$	$[O_2]_0$	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}

What is the rate law?

The questions below refer to the following diagram:



27. Why is this reaction considered to be exothermic?
    a) Because energy difference B is greater than energy difference C.
    b) Because energy difference B is greater than energy difference A.
    c) Because energy difference A is greater than energy difference C.
    d) Because energy difference B is greater than energy difference C plus energy difference A.
    e) Because energy difference A and energy difference C are about equal.

28. At what point on the graph is the activated complex present?
    a) point W
    b) point X
    c) point Y
    d) point Z
    e) none of these

29. If the reaction were reversible, would the forward or the reverse reaction have a higher activation energy?
    a) The diagram shows no indication of any activation energy.
    b) The forward and reverse activation energies are equal.
    c) The forward activation energy would be greater.
    d) The reverse activation energy would be greater.
    e) None of these.

30. What would happen if the kinetic energy of the reactants was not enough to provide the needed activation energy?
    a) The products would be produced at a lower energy state.
    b) The rate of the reaction would tend to increase.
    c) The activated complex would convert into products.
    d) The reactants would continue to exist in their present form.
    e) The products would form at an unstable energy state.

31. The rate constant for a reaction at 40.0°C is exactly 3 times that at 20.0°C. Calculate the Arrhenius energy of activation for the reaction.
    a) 9.13 kJ/mol
    b) 5.04 kJ/mol
    c) 41.9 kJ/mol
    d) 3.00 kJ/mol
    e) none of these

A general reaction written as A + 2B → C + 2D is studied and yields the following data:

$[A]_0$	$[B]_0$	Initial $\Delta[C]/\Delta t$
0.150 *M*	0.150 *M*	8.00×10^{-3} mol/L·s
0.150 *M*	0.300 *M*	1.60×10^{-2} mol/L·s
0.300 *M*	0.150 *M*	3.20×10^{-2} mol/L·s

32. What is the order of the reaction with respect to B?
    a) 0
    b) 1
    c) 2
    d) 3
    e) 4

33. What is the order of the reaction with respect to A?
    a) 0
    b) 1
    c) 2
    d) 3
    e) 4

34. What is the overall order of the reaction?
    a) 0
    b) 1
    c) 2
    d) 3
    e) 4

35. What is the numerical value of the rate constant?
    a) 0.053
    b) 1.19
    c) 2.37
    d) 5.63
    e) none of these (A-D)

Use the following to answer questions 36-38:

The kinetics of the reaction A + 3B → C + 2D were studied and the following results obtained, where the rate law is:

$$-\frac{\Delta[A]}{\Delta t} = k[A]^n[B]^m$$

For a run where $[A]_0 = 1.0 \times 10^{-3}$ *M* and $[B]_0 = 5.0$ *M*, a plot of ln [A] versus *t* was found to give a straight line with slope = -5.0×10^{-2} s^{-1}.
For a run where $[A]_0 = 1.0 \times 10^{-3}$ *M* and $[B]_0 = 10.0$ *M*, a plot of ln [A] versus *t* was found to give a straight line with slope = -7.1×10^{-2} s^{-1}.

36. What is the value of *n*?
    a) 0
    b) 0.5
    c) 1
    d) 1.5
    e) 2

37. What is the value of *m*?
    a) 0
    b) 0.5
    c) 1
    d) 1.5
    e) 2

38. Calculate the value of *k* (ignore units).
    a) 22
    b) 10
    c) 50
    d) 1.1
    e) none of these

For each of the following compounds:
    a) Draw the Lewis structure.
    b) Give the electonic and molecular shape of the molecule
    c) Indicate the polarity of the molecule.

39. AlF_3

40. NH_3

41. How many of the following molecules have all of their atoms in the same plane?
    $H_2C{=}CH_2$ OF_2 H_2CO NH_3 CO_2 $BeCl_2$

    a) 3
    b) 4
    c) 5
    d) 6
    e) 7

T F The shape of an ammonia molecule is tetrahedral.

T F The shape of a carbon dioxide molecule is linear.

42. In the molecule C_2H_4 the valence orbitals of the carbon atoms are assumed to be
    a) not hybridized
    b) *sp* hybridized
    c) sp^2 hybridized
    d) sp^3 hybridized
    e) *dsp* hybridized

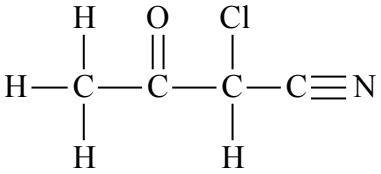
43. Atoms that are sp^2 hybridized form ____ pi bond(s).
    a) 0
    b) 1
    c) 2
    d) 3
    e) 4

44. The hybridization of the central atom in O_3 is:
    a) *sp*
    b) sp^2
    c) sp^3
    d) dsp^3
    e) d^2sp^3

45. What hybridization is predicted for the nitrogen atom in the NO_3^- ion?
    a) sp^2
    b) sp^3
    c) dsp^3
    d) d^2sp^3
    e) none of these

46. Which of the following does not contain at least one pi bond?
    a) HCN
    b) O_3
    c) C_2H_4
    d) C_3H_8
    e) All of the above (A-D) contain at least one pi bond.

Consider the molecule and the following hybridization choices:



47. What is the hybridization of the carbon atom that is double-bonded to oxygen?
    a) sp
    b) sp^2
    c) sp^3
    d) dsp^3
    e) d^2sp^3

48. What is the hybridization of the carbon atom that is bonded to chlorine?
    a) sp
    b) sp^2
    c) sp^3
    d) dsp^3
    e) d^2sp^3

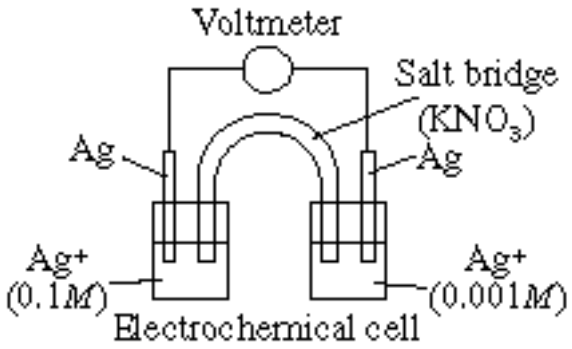
49. What is the hybridization of the nitrogen atom?
    a) sp
    b) sp^2
    c) sp^3
    d) dsp^3
    e) d^2sp^3

50. What is the hybridization of the oxygen atom?
    a) sp
    b) sp^2
    c) sp^3
    d) dsp^3
    e) d^2sp^3

MCAT

Passage II

An experimenter wishes to test the hypothesis that a concentration difference alone can produce a voltage in an electrochemical cell. In order to test her hypotheses, she constructs the cell shown below, where both sides of the cell contain AgNO3, with concentrations shown in the diagram. She will use the voltmeter shown to determine what voltage, if any, exits across the electrodes at different times after the circuit is closed.



The table that follows shows the voltage in the cell as a function of the time that current has been allowed to flow in the circuit. It also displays the concentration of silver ion on each side of the cell.

t(s)	v(volts)	[Ag^+] on left (mol/L)	[Ag^+] on right (mol/L)
0	0.1180	0.1000	0.0010
10	0.0721	0.0953	0.0057
20	0.0567	0.0910	0.0100
30	0.0472	0.0872	0.0138
40	0.0404	0.0837	0.0173
50	0.0351	0.0805	0.0205
•			
•			
•			
1000	0.0000	0.0505	0.0505

Passage II (Questions 9-14)

9. The purpose of the salt bridge in the experiment is to:

a. allow K+ and NO3- ions to flow from one half cell to another in order to keep the solution electrically neutral.
b. conduct Ag+ ions from right to left.
c. allow electrons to flow from left to right.
d. conduct Ag+ ions from left to right.

10 . Passage II (Questions 9-14)

The reduction potential for Ag+, $E°$ is 0.799 volts. For the net reaction that occurs in the overall cell, what is $E°$cell in v?

a. -0.799
b. 0
c. 0.009
d. 0.799

11 . Passage II (Questions 9-14)

For how many time values listed in the chart does the value of V change by more than 0.010 v from the previous time?

a. 2
b. 3
c. 1
d. 4

12 . Passage II (Questions 9-14)

If the apparatus were modified so that the solutions on each side could mix through a horizontal connecting tube, the measured voltages would:

a. drop rapidly to zero.
b. take a longer time to reach zero.
c. increase from those shown in the table.
d. be unchanged from those given in the table.

13 . Passage II (Questions 9-14)

Which of the following best describes the relationship among the voltage and the concentrations on each side?

a. As time passes, Ag+ ions flow through the salt bridge from left to right, causing the voltage to drop.
b. As time passes, electrons flow through the wire from right to left, causing the concentration gradient to decrease and the voltage to drop.
c. As time passes, electrons flow through the salt bridge from left to right, causing the ions to equilibrate and the voltage to drop.
d. As time passes, electrons flow through the wire from left to right, causing the ions to equilibrate and the voltage to drop.

14 . Passage II (Questions 9-14)

Suppose that $C1$ represents the concentration of silver ion on the left of the cell, while $C2$ represents the concentration on the right. Which of the following best describes the relation between $C1$ and $C2$?

a. $C1 - C2$ is constant, owing to conservation of Ag+ ion.
b. $C1 + C2$ is constant, owing to conservation of Ag+ ion.
c. $C1 + C2$ is constant, owing to conservation of charge.
d. $C1 - C2$ is constant, owing to conservation of charge.