CHEMISTRY 204
Hour Exam III
April 25, 2019
Dr. D. DeCoste

Name _____

Signature _____

T.A. _____

Section _____

This exam contains 23 questions on 11 numbered pages. Check now to make sure you have a complete exam. You have two hours to complete the exam. Determine the **best** answer to the first 20 questions and enter these on the special answer sheet. Also, circle your responses in this exam booklet. **Show all of your work and provide complete answers to questions 21, 22 and 23.**

1-20	(60 pts.)	_____
21	(20 pts.)	_____
22	(30 pts)	_____
23	(10 pts.)	_____
Total	(120 pts)	_____

Useful Information:

- Unless otherwise noted, all solutions referred to on this exam are aqueous solutions at 25°C.
- 760 torr = 1.00 atm
- R = 0.08206 Latm/molK = 8.3145 J/Kmol
- K = °C + 273
- $N_A = 6.022 \times 10^{23}$

$P_{soln} = \chi_{solvent} P°_{solvent}$ $P_{total} = P_A + P_B = \chi_A P°_A + \chi_B P°_B$

$\pi = iMRT$

$\Delta T = iK_f m_{solute}$ $\Delta T = iK_b m_{solute}$

K_f = 1.86 K/m for water K_b = 0.51 K/m for water

$\varepsilon = \varepsilon° - \frac{0.0591}{n} \log(Q)$ F = 96,485 coulombs 1 Ampere = 1C/s

$\Delta G° = -nF\varepsilon°$

1. You have a solution of liquid A (pure vapor pressure = 150.0 torr) and liquid B (pure vapor pressure = 450.0 torr). The solution is placed in a closed container and allowed to come to equilibrium with its vapor. The vapor pressure above the solution is measured at 25°C and found to be 185.0 torr. Determine the composition of the **vapor** (by moles).

   a) 11.67% A
   b) 28.38% A
   c) 62.83% A
   d) 71.62% A
   e) 88.33% A

2. You know the freezing point of an aqueous solution. In order to use this number to calculate the osmotic pressure of the solution, how many of the following must be true?

   - The solution is relatively dilute.
   - The solute is ionic.
   - The solute has a van't Hoff factor (i) equal to 1.
   - $\Delta H_{solution}$ is negative.
   - $\Delta H_{solution}$ is positive.

   a) 0 b) 1 c) 2 d) 3 e) 4

3. Consider the following data at the same temperature for a mixtures of liquids A and B (note: the vapor pressures are in an undefined unit and given for their relative values):

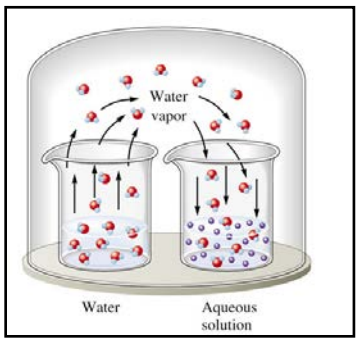
Mole fraction of A	Vapor Pressure
0	10.0
0.400	31.4
1.00	70.0

	Liquid A	Liquid B
a)	Acetone	Water
b)	Water	Acetone
c)	Water	Heptane
d)	Hexane	Heptane
e)	Heptane	Water

4. You dissolve 1.00 g $MgCl_2$ in enough water to make 100.0 mL of solution at 25°C. Assuming that 15.0% of the $MgCl_2$ exists as ion pairs, determine the osmotic pressure (π) of the solution.

   a) 2.56 atm
   b) 4.75 atm
   c) 6.53 atm
   d) 6.93 atm
   e) 7.71 atm

5. Recall the following system discussed in your text (and lecture!):



First, 1.00 kg of water was added to each beaker. Then, 360.0 g of NaCl was added to the beaker on the right to make a saturated solution. The beakers were covered as shown above.

Given that the system is at a constant temperature of 25°C and that the vapor pressure of pure water is 23.8 torr at 25°C, determine the vapor pressure of the system at equilibrium. Assume ideal conditions.

a) 19.6 torr b) 21.4 torr c) 22.5 torr d) 23.8 torr e) 25.0 torr

6. Which of the following is expected to have the lowest vapor pressure at 25°C?

a) propane
b) dimethyl ether
c) ethanal (also known as acetaldehyde)
d) ethene (also known as ethylene)
e) ethyl alcohol

7. Which of the following statements is/are correct?

a) The value of $\mathcal{E}$ is equal to zero in a galvanic cell at equilibrium.

b) The value $\mathcal{E}$ is equal to zero in any concentration cell.

c) The value of $\mathcal{E}^\circ$ is equal to zero in any galvanic cell at equilibrium.

d) The value of $\mathcal{E}^\circ$ can never be equal to zero in a galvanic cell with a potential.
e) At least two of the above choice (a-d) are correct.

8. For how many of the following would bubbling $Cl_2(g)$ through the molten ionic compound cause a reaction?

- KI(l)
- KBr(l)
- NaF(l)
- NaCl(l)

a) 0 b) 1 c) 2 d) 3 e) 4

9, 10. Given the following two standard reduction potentials,

$M^{3+} + 3e^- \rightarrow M$ -0.20 V
$M^{2+} + 2e^- \rightarrow M$ -0.65 V

9. Solve for the absolute value (magnitude) of the standard reduction potential of half-reaction $M^{3+} + e^- \rightarrow M^{2+}$.

a) 0.45 V b) 0.70 V c) 0.85 V d) 1.90 V e) 2.35 V

10. Is the sign of the standard reaction potential in Problem #9 positive or negative?

a) Positive
b) Negative

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11. Consider an electrochemical cell with a zinc electrode immersed in 1.0 *M* Zn^{2+} and an unknown metal "M" electrode immersed in 1.0 x 10^{-3} *M* "M^{2+}". The cell potential at 25°C is 0.53 V. Determine the identity of "M".

a) Fe
b) Zn
c) Sn
d) Cu
e) We cannot determine the identity of the metal with this information.

12. The reaction that occurs in a lead storage battery for a car can be represented as follows:

$$Pb + PbO_2 + 2SO_4^{2-} + 4H^+ \rightarrow 2PbSO_4 + 2H_2O$$

Suppose you are starting a car on a cold morning and a current of 250.0 amperes is drawn for 31.4 seconds from the battery. How many grams of lead would be consumed?

a) 8.55 x 10^{-3} g
b) 0.0171 g
c) 4.21 g
d) 8.43 g
e) 16.9 g

13. A fuel cell is designed to react rubbing alcohol (isopropyl alcohol) with oxygen to produce carbon dioxide and water. If you knew the maximum work that one mole of rubbing alcohol would yield, you could determine the theoretical maximum voltage of this cell. In making this calculation, what is the value of *n*?

a) 2 b) 6 c) 9 d) 12 e) 18

14. How many of the following alcohols are tertiary (3°) alcohols?

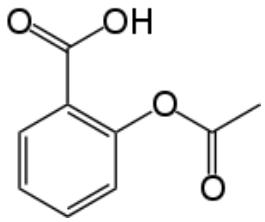
I. 2-methyl-1-propanol
II. 2-methyl-2-propanol
III. 2-butanol
IV. 3,3-dimethyl-1-butanol

a) 0 b) 1 c) 2 d) 3 e) 4

15. Complete the following sentence (hint: draw out the functional groups to answer this question). An ester is similar to a carboxylic acid as

a) a primary alcohol is similar to a secondary alcohol.
b) an amine is similar to a ketone.
c) an alcohol is similar to an ether.
d) an aromatic ring is similar to a polymer.
e) a ketone is similar to an aldehyde.

16. Which functional groups are present in aspirin (shown below)?



a) alcohol, ether, ketone
b) secondary alcohol, ketone, ester
c) carboxylic acid, ether
d) aldehyde, ester
e) carboxylic acid, ester

17. Which of the following names is a **correct** one?

a) 3,4-dichloropentane
b) 1,1-dimethyl-2,2-diethylbutane
c) *cis*-1,3-dimethylpropane
d) 2-bromo-1-chloro-4,4-diethylheptane
e) At least two of the above are correct.

18. How many of the following groups of two compounds have the same molecular formulas?

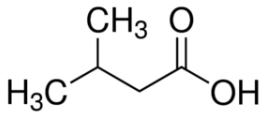
- dimethyl ether and ethanol
- propanol and propanal
- propanone and propanol
- dimethyl ether and methanol

a) 0 b) 1 c) 2 d) 3 e) 4

19. As a question on an organic chemistry exam, you are given the name of an alcohol, an ester, a carboxylic acid, a ketone, an amine, and an aldehyde, and asked to draw their structures. In drawing the structures for all of these, what is the **minimum** number of oxygen atoms you must include?

a) 5 b) 6 c) 7 d) 8 e) 9

20. Provide the best name for the following compound.



a) 3-methylbutanoic acid
b) 2-isopropylethanoic acid
c) 3-methylpropanoic acid
d) 2-methylpropanoic acid
e) 2-methylbutanoic acid

21. For the following questions, please provide complete, yet concise, explanations and show all work for any calculations.

    a. You have climbed Mt. Everest in Tibet, which has an elevation of ~5.5 miles. The atmospheric pressure at the top of Mt. Everest is 239 torr.

        i. The boiling temperature on Mt. Everest is lower than 100°C. **Why is this true?** Also, **explain** why a liquid boils **using the concept of vapor pressure**. **[5 points]**

        ii. You feel homesick for the boiling water in Champaign and want to get the water on Mt. Everest to boil at 100°C, so you add salt (NaCl). **Explain** why adding a non-volatile solute such as salt will increase the boiling temperature of water. **[3 points]**

21. iii. You start with 4.00 liters of water at 25°C (at this temperature water has a density of 0.99713 g/mL). Assuming infinite solubility of NaCl, no ion pairing, and ideal behavior, **determine the mass of sodium chloride** you would need to add to your water to get the solution to boil at 100°C at the top of Mt. Everest. **Explain your thought process** and **show all work**. **[7 points]**

b. You are back in Champaign just in time for π day and to celebrate you decide to make a solution of methanol and water that has a vapor pressure of 31.4 torr at 25°C. You make the solution and seal it in a container, allowing the solution and its vapor to come to equilibrium. Given that at 25°C water has a vapor pressure of 23.8 torr and the vapor pressure of methanol is 97.7 torr, determine the composition (% by moles) of the solution and of the vapor. Assume ideal behavior. **Show all work. [5 points]**

22. These questions concerns some of our electrochemistry lecture demonstrations. Please provide complete, yet concise, explanations and show all work for any calculations.

    a. During the first electrochemistry lecture, I placed an excess of copper wire in 100.0 mL of a 0.100 *M* $AgNO_3$ solution. After a few minutes, silver metal was observed covering the wire and the solution began to turn blue from the Cu^{2+} ions in solution. Eventually, the system reached equilibrium.

        i. Determine the **concentrations** (in molarity) **of Ag^+ and Cu^{2+}** and the **mass of silver metal** when the system reached equilibrium. **Show all work**. **[8 points]**

22. ii. As we discussed, Cu^{+} is also produced but at a much lower concentration than Cu^{2+}. Solve for the **equilibrium concentration of Cu^{+}** (in molarity). **Show all work. [4 points]**

b. In lecture I also constructed a standard galvanic cell with Zn, Zn^{2+}, Cu, and Cu^{2+}.

The AA battery provides 1.5 V. Suppose we wanted to use the Zn/Cu cell that we made in lecture to power something requiring the AA battery. Keeping the ion of higher concentration (either Zn^{2+} or Cu^{2+}) at 1.00*M*, **determine and label** the concentration of the other ion. **Briefly explain** how you know which ion has the lower concentration and **show all work**. **[6 points]**

22. c. During the final electrochemistry lecture, I electroplated copper onto a spoon by placing a spoon (cathode) in an aqueous solution with 1.00*M* Cu^{2+} ions and a copper anode, and then providing current.

i. The reduction potential for Cu^{2+} to Cu is positive, so why doesn't copper form on the spoon without supplying electricity? **[3 points]**

ii. Are there any metals we could place in an aqueous solution of Cu^{2+} that would work to get copper metal from the solution without providing electricity? If not, **explain why not**. If so, **provide an example** that would work. **In either case, defend your answer with words and numbers. [6 points]**

iii. One metal that would not work to plate out copper metal is sodium (so change your answer to part ii if you had that one). **Why wouldn't sodium work** in this case? **Defend your answer with words and numbers** and **write the equation for the reaction that will occur**. **[3 points]**

23. For each of the following, **neatly** draw the structures and name the compounds.

a. A friend at another university drops the name "2-ethyl-3-methyl-5-isopropylhexane" during a conversation. You chuckle and say, "Surely you mean _____." What is the **correct name** of the molecule your friend incorrectly named? **Draw the structure** and **support** the name. **[4 points]**

b. You and a friend each have a compound with the formula C_5H_{12} and you each react your compound with chlorine gas. It turns out that you end up with three distinct monochlorination products and your friend ends up with only one.

Name both reactants (labeling which is yours and which is your friend's) along with **all products**. Also, **draw all structures** (reactants and products). **[6 points]**